HANDBOOK OF HYGIENE

AND

SANITARY SCIENCE

A

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BY

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SEVENTH EDITION

LONDON
J. & A. CHURCHILL
11 NEW BURLINGTON STREET
1892

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PREFACE

I VERY much regret that this Handbook has been out of print for more than a year. While the delay in preparing a new edition has been much interfered with by official duties, it has been mainly due to my earnest endeavour to render the work still more worthy of the very favourable reception which has been accorded to it ever since it was first published.

With the exception of a few chapters, all of which have been carefully revised and brought up to date, the whole of the book has been re-written; and in spite of every effort to compress, the present edition has been enlarged to the extent of more than two hundred pages, and contains a considerable number of new wood-cuts to illustrate more clearly those portions of the text which apply to ventilation, sanitary fittings and drainage, house-building, isolation hospitals, and parasitic diseases.

Though the general plan of the work has been as far as possible maintained, several of the chapters have been re-arranged to form a more connected sequence than in previous editions; and two new chapters have been

inserted on Climate and Meteorology, and Disposal of the Dead.

Amongst the chapters which have been wholly, or in great part, re-written, I would refer more particularly to the chapters on Food, Water-Supply, Removal of Excreta and House Refuse, Purification and Utilisation of Sewage, Dwellings, Hospitals, Communicable Diseases, Prevention and Disinfection, Vital Statistics, and Sanitary Law and Official Duties.

In the chapter on Food, I have inserted new tables of food equivalents in relation to work, and have given a *résumé* of the diseases which render the flesh of animals unfit for the food of man, and the chief points which have to be attended to in the examination of food. In this chapter, too, I have discussed in detail the various outbreaks of food-poisoning and the most marked features of recent milk epidemics. The several chapters on Air, Ventilation and Warming, Air Analysis, Water, Water Analysis, and outbreaks of disease traceable to polluted water, have all of them been carefully revised, and brought up to date. In the chapter on Removal of Sewage and House Refuse, I have endeavoured to describe systematically the most recent and approved kinds of sanitary fittings, the principles of sanitary plumbing, and the details of sanitary engineering generally, in respect to house-drainage and public sewerage. In addition to a large amount of other information, the chapter on Sewage Disposal contains a survey of the most successful methods

adopted for the purification of sewage, and for the destruction or treatment of dry house-refuse and street sweepings. In the chapter on Dwellings will be found a digest of the building bye-laws issued by the Local Government Board; while the chapter on Hospitals has been further illustrated by wood-cuts of the block plans of isolation hospitals which accompany the Board's latest memorandum on the subject, together with structural details.

In the chapter on Communicable Diseases, an attempt has been made to summarise the most recent advances in bacteriological research,—a task which was rendered all the easier by the admirable series of reports of the Proceedings of the 1891 Congress of Hygiene and Demography which appeared in *Public Health* and other Medical Journals, and which may be said to epitomise the views on the subject entertained by the leading bacteriologists of the day, both in this country and abroad. In this chapter, too, it will be seen that I have endeavoured to discuss briefly not only the etiology, period of incubation, symptoms, and mode of propagation of the so-called principal zymotic diseases, but have described a large number of other diseases which, though they do not come under the restrictions of sanitary law, are certainly communicable, and have therefore been included under this general category. The practical value of the chapter on Prevention and Disinfection has been greatly enhanced, inasmuch as the proof sheets were kindly revised by Dr.

Franklin Parsons of the Local Government Board, whose experiments and reports on various kinds of disinfecting apparatus, and other contributions on disinfectants and disinfection, are so well-known. In re-writing the chapter on Vital Statistics, I have to acknowledge my indebtedness to Dr. Newsholme's standard work on that subject, and to the valuable writings of the late Dr. Farr, edited by Mr. Noel Humphreys. In addition to concise treatment of the whole subject, I have in this chapter endeavoured to explain how estimates of population are calculated, general death-rates corrected, life-tables for sanitary purposes constructed, and statistical fallacies avoided.

The concluding chapter on Sanitary Law and Official Duties contains a full digest of the various sections of the Public Health Act 1875, and of the numerous other Sanitary Acts passed from time to time up to the close of 1891, which more immediately concern the duties of Medical Officers of Health, Local Surveyors, and Sanitary Inspectors. In this chapter I have endeavoured to embody a large amount of information conveyed in annotations and references to previous portions of the work; and have included a summary of the Model Bye-laws issued by the Local Government Board, and detailed instructions with regard to routine work, legal proceedings, and reports.

Though I have striven throughout to enhance the value of the work as a text-book for medical students and for candidates preparing for public health diplomas, and

other sanitary examinations, I have constantly kept in view the main object for which the work was first written, namely, that it should form a practical work of reference to medical practitioners generally, as well as a guide to sanitary officials, and all who are interested in sanitary progress. Exclusive of portions of the chapters dealing with food and work, water analysis, air analysis, meteorological observations, sanitary engineering, sanitary plumbing, and vital statistics, the whole of the work has therefore, as far as possible, been kept free from technicalities and problems so as to render the bulk of the text easily understood by the general reader. But in order to supply the necessary information for the wider range and greater stringency of public health examinations, I felt it incumbent on me to re-write almost the whole of the work; and in the Appendix I have given numerous data with engineering and other problems together with their solutions, and examples of questions given at recent examinations, which are intended specially for the use of candidates preparing for public health diplomas. For the selection of problems and their solutions, I am greatly indebted to the help which I have received from Dr. Brock, D.Sc. Edinburgh, Medical Officer of Health for Mid-Lothian, and for much information with regard to sanitary engineering data and formulæ, to Mr. Willcox, C.E., President of the Student's Society of Civil Engineers, Birmingham.

Although I have all along expressed my great

indebtedness to the standard work of the late Professor Parkes and its later editions, I wish also to acknowledge very frankly my obligations to the several excellent text-books on Public Health, Sanitary Plumbing, and Sanitary Engineering, which have recently been published, and, indeed, I have spared no efforts to collect reliable information from all the latest sources.

I wish also to again express my grateful thanks to Sir George Buchanan, whose recent retirement from the Public Health Service all will regret, and to his successor Dr. Thorne Thorne, for favouring me with copies of the most recent reports, memoranda, and general orders, issued by the Local Government Board. Although I have avoided, as heretofore, burdening the text with foot-notes, it will be seen that frequent reference is made throughout, not only to other authorities, but also to the official reports of the Medical Department; and in this respect I may mention some typical reports, such as those of Sir George Buchanan on the relation of phthisis to dampness of soil; Dr. Thorne Thorne's report on hospitals; Dr. Franklin Parsons's report on disinfection and disinfecting apparatus; various reports on milk epidemics and polluted water-supplies; Dr. Ballard's reports on food-poisoning, trade nuisances, and epidemic diarrhœa; Mr. Power's and Dr. Barry's reports on smallpox epidemics; and the researches of Dr. Klein and others into the bacteriology and etiology of disease. A digest, or full quotation has also been given in various

parts of the work of the latest memoranda issued by the Local Government Board in respect to isolation hospitals, school closure, vaccination and re-vaccination, preventive measures, and annual reports; while the General Orders applying to the duties of Medical Officers of Health and Sanitary Inspectors issued in 1891, and the Cholera Order of 1890 have also been inserted *in extenso.*

A glance at the Table of Contents will show how wide and varied are the subjects treated, and perusal of the work will, I hope, satisfy the reader that I have honestly striven to make this edition a reliable Handbook of the most recent advances in Public Hygiene, Sanitary Science, and Sanitary Law.

7 Avon Place, Warwick.
May 1892.

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Page 25, line 23, *for* Dr. Pavoy *read* Dr. Pavy.
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CHAPTER I.—INTRODUCTORY

PUBLIC HEALTH AND PREVENTABLE DISEASE

Public Hygiene may be defined as that branch of sanitary science which concerns the physical condition of communities. It embraces a consideration of the various influences operating upon society, whether for its material good or its actual deterioration, with the view of extending the former, and preventing, or ameliorating, as far as possible, the effects of the latter. It involves the enactment of laws by which the safety of the whole may be protected against the errors of a part, and, above all, it aims at the prevention of disease by the removal of its avoidable causes. In a wide sense, therefore, the science of public hygiene enlists the services of the people themselves in continuous efforts at self-improvement; of the teachers of the people, to inculcate the best rules of life and action; of physicians in preventing as well as curing disease; and of lawgivers, to legalise and enforce measures of health-preservation. But while it is the special province of the medical profession, as guardians of the public health, to study the causes of physical deterioration and disease, and to point out how far these causes may be controlled or averted, the general well-being of the people must mainly depend on their own exertions and self-restraint.

Sanitary improvements in man's material surroundings will not compensate for social transgressions against laws of morality; for public virtue is essential to public health, and both to national prosperity.

The time, however, has gone by when people can be dragooned into cleanliness or be made virtuous by police regulations; and hence it is that the most thoughtful among practical reformers of the present day base their hopes of sanitary progress on the education of the masses as the real groundwork of national health. The people must be taught that good conduct, personal cleanliness, and the avoidance of all excesses, are the first principles of health-preservation; that mental and physical training must go hand in hand in the rearing and guidance of youth; and that morality does not consist so much in a blind observance of the formulæ of empty creeds as in a hearty submission to precepts of health. Nor is this all. They must be interested systematically in the general results of sanitary progress, and become more intimately acquainted with the social and material causes by which it is impeded. Unless a knowledge of these fundamental principles of hygiene be widely disseminated amongst them, it is in vain to expect that legislative enactments, however well devised, will succeed in raising the standard of public health to any considerable extent. But there are hopeful signs of progress even in this direction. The teaching of physiology and the laws of health, which is being gradually introduced into many schools, will doubtless be productive of much good amongst the rising generation; while the large share of attention which the discussion of sanitary questions is already receiving in the public press is the best evidence of the steady growth of intelligent conviction as regards all matters affecting the preservation of health and the prevention of disease.

Taking, then, this wide view of the scope of public

hygiene, it will, I trust, prove alike interesting and useful if, by way of introduction, I give a brief historical sketch of its various phases, and more particularly of its progress during recent years. For sanitary science, in the broad sense of the term, is knit up with the life-history of every nation, and enters largely into the history of civilisation. It figures prominently in the Mosaic code of the Jewish race, and its instructions and preventive measures, as exemplified in that code, have accounted largely for the greater comparative longevity of the Jews, for their extraordinary immunity from the recurring epidemics of the Middle Ages, and for the widespread, though silent influence which they have long exercised, and still exercise to the present day.

Or let us glance at those grand old Greeks who have left us such a rich store of philosophy, literature, and art. It is true that though their sanitary code, propounded by Lycurgus, was severe and cruel, yet the means which they adopted in the care and cultivation of their bodily physique, and the development of their intellectual faculties made them the civilisers of the old world and the exemplars of modern times. But the Greeks, with all their wisdom and physical culture, knew very little of the causes of disease as it affects communities, and they accepted the terrible epidemics with which they were visited as manifestations of offended deities, or, at the best, as afflictions which could neither be avoided nor prevented. Their decline and fall as a nation were due to the luxury into which they lapsed, and the lax morality which ultimately became their ruin and opprobrium.

Referring, now, to the Romans, the other powerful nation of antiquity, we find that though they contributed but little to sanitary science, they have left some wonderful examples of sanitary engineering on a large scale. Their *Cloaca Maxima*, for example, and the aqueduct for

conveying water from the hillsides, some thirty miles from Rome, to the city, were works of such stupendous magnitude that they have seldom been equalled or surpassed even at the present day. But the Roman Empire, like that of the Greeks, was destined to pass away, and those who have studied the social causes of its decay attribute its ultimate decline in no small degree to the epidemics which repeatedly devastated the population in the early centuries of the Christian era.

We next pass on to what have been termed the dark or Middle Ages, and to the health history of England. The accounts at first are very meagre, but when they become more numerous and reliable they tell us of frequent visitations of plague, pestilence, and famine—mixed up with stories, strange and incredible, of armies fighting in the air, showers of blood, terrible earthquakes, and the like—all of them showing how deep-rooted was the belief in the supernatural as regards epidemic disease and its causes. If, however, we look at the habits and habitations of our forefathers, we have no difficulty in accounting for the fearful mortality which prevailed amongst them. Personal cleanliness was utterly neglected. Clothing was immoderately thick and warm, and was seldom changed night or day. The diet was coarse, consisting chiefly of flesh meats highly seasoned. Strong wine or ale was drunk early in the morning, and often far into the night; in short, gluttony and intemperance were prominent characteristics of the sturdy fighting Briton of mediæval times.

Then, as regards his dwelling, we find that the towns and villages were composed for the most part of hovels, with mud walls and thatched roofs. "The floors of the houses," to quote from a well-known letter of the learned Erasmus, "were generally made with loam strewn with rushes, constantly put on fresh without removing the old, lying there in some cases for twenty years, concealing

fish bones, broken victuals, and other filth," so that one can quite credit him when he says further, "If even twenty years ago I had entered into a chamber which had been uninhabited for some months, I was immediately seized with fever." The streets were unpaved, generally covered with clay and rushes, concealing all sorts of abominations; moreover, they were dark, narrow, and tortuous, and without sewers or drains. The rural population, on the other hand, were scattered in slight hovels over wild woods, dreary wastes, and undrained marshes, so that ague and rheumatism were always rife amongst them; and in times of scarcity, which were common enough, they were sure to suffer from famine. Add to all this, that there was constant fighting of some sort going on. Kings were warring against powerful subjects or foreign foes. Cities and towns were walled-in fortresses; and the roads were beset with marauders and highwaymen. Dogberries watched the streets but did not ward them, bravoes stabbed, burglars were plentiful, and amongst all classes life was held very cheap. Those, indeed, were days in which Mr. Darwin's doctrine of survival of the fittest was exemplified to the fullest extent; the weakly went to the wall, and left, on the whole, only those of iron constitutions to perpetuate a brave, hardy, and pushing race, which increased in numbers slowly, if at all, for centuries.

We thus see that conditions inimical to health were abundant everywhere. The walled-in cities were highly favourable to overcrowding and stagnant air; the large armies, which were in constant motion, conduced greatly to the spread of epidemic disease; while personal uncleanliness and intemperate habits made the people ready victims of disorders of all kinds. It is not surprising, therefore, that fevers and devastating epidemics were prevalent; and as instances in point, I may mention the

following:—For example, in the twelfth century, there were fifteen widespread epidemics and many famines; in the thirteenth century, twenty epidemics and nineteen famines; and in the early part of the fourteenth century there were eight epidemics and more famines. And these epidemics, it should be remembered, were not local outbreaks appearing only here and there, but they spread so far and wide that each and all of them were regarded as visitations of national disaster.

And now we come to the fatal year of 1348, when the Black Death or Great Mortality, as it was called, first appeared in England. It is believed to have been an aggravated outbreak of the Oriental Plague, which was then devastating Europe as it had devastated the East. It was an eminently contagious disease—imported, no doubt, in the first instance; but when once it gained a footing on our shores, it spread with such terrible rapidity, that within a few months almost every town and village throughout the country had been attacked, and in some places only a fourth part of the inhabitants were left alive. In London alone 100,000 fell victims to the disease, and 50,000 corpses were interred in one burial-ground, heaped together, layer upon layer, in large pits. Throughout Europe it has been estimated that twenty-five millions, or a fourth part of the entire population, were swept away. Imagination fails to realise the misery and horrors of the time. The sick died untended, charity was dead, and hope extinguished—everywhere there was terror and black despair.

Without noticing other epidemics which followed the epoch of the Black Death, the next great pestilence which ravaged the country, and known as the Sweating Sickness, broke out in 1485. Unlike the Black Death and the Oriental Plague, which reappeared in the sixteenth and seventeenth centuries, it did not originate in a foreign

country to be conveyed by infection to our own shores but it sprang into existence in this, and was no doubt generated and propagated by the insanitary conditions of dwellings and towns, and the filthy and intemperate habits of the people. For the most part it attacked robust middle-aged adults, men fond of good living, and those amongst the poorer classes who were described as "idle persons, good ale drinkers, and tavern haunters." Its onset was quick and its termination rapid, the victim generally dying within twenty-four hours; while the mortality was so great that in many parts of the country half of the male adult population were swept away. During the latter part of the fifteenth century, and the first half of the sixteenth, this pestilence reappeared no less than five times, its last visitation having occurred in 1551. Yet it must not be forgotten that this sixteenth century, with its long list of ravaging diseases, gave us, nevertheless, the heroes of the Elizabethan age, our triumph over Spain, and our English Reformation. But progress in sanitary defence was slow, tedious, and tentative. Indeed, the extraordinary vitality and indomitable pluck of the English race would almost appear to have been the sole defences against national decay and disaster, for during long years to come there was but little improvement in the homes or habits of the people. It was not until the Plague, which was the next great pestilence after the Sweating Sickness, had repeatedly devastated the country, and the great fire which swept away the crowded and filthy homes of London in 1666 occurred, that people began to appreciate, though in a faint and glimmering way, the principles of prevention. The Plague died out with the fire, but smallpox, jail fever, malignant sore throat, ague, scurvy, and other controllable diseases, still continued to contribute to the excessive mortality of the seventeenth century.

But now we come to the dawn of a better day. The gradual improvements in agriculture, manufactures, and commerce were adding steadily to the comforts of life. Food was becoming more plentiful, and the diet less coarse. Vegetables, and more especially the potato, were becoming much more generally used; fresh meat was taking the place of salted meat, which had hitherto constituted such a large part of the English dietary; while tea and coffee were to some extent replacing the strong ale and ardent spirits which had formerly proved such a baneful source of disease. People, too, were beginning to recognise the value of cleanliness of person and home. The introduction of soap and soda made washing easier, and cotton and linen articles of clothing were gradually coming into more general use. Thus far, then, it may be said that the seventeenth century, although characterised by no great advance in sanitary progress, witnessed, nevertheless, some considerable improvements of an incidental and indirect kind. The gradual emancipation from the thraldom of filth had begun, and precautionary measures against the spread of disease in the form of a rough-and-ready system of quarantine were here and there attempted. But the great purifier of the century was the memorable fire of London, which consumed everything from the Tower to Temple Bar, destroying 81 out of the 97 parishes within the city boundaries, and two of the parishes outside the walls. The old wooden houses with their overhanging stories, and the huge signboards swinging across the narrow, winding, filthy, unpaved streets, were swept away; and though the model city which Sir Christopher Wren had planned was not destined to be realised, better houses were constructed, wider streets laid out, and sanitary conditions in other respects were considerably improved.

Coming now to the health history of the eighteenth

century, we find that three terrible scourges, namely, the Black Death, the Sweating Sickness, and the Plague, have finally disappeared from the bills of mortality. And their disappearance, as we have seen, is not to be attributed to any conscious or well-sustained efforts in the way of prevention, but to the silent influence of the onward progress of civilisation. We now, however, enter upon an era in which observation and induction begin to play a part in the prevention of human suffering, when the physical causes of disease receive fuller appreciation, and when it is at last recognised that these causes can be inquired into and dealt with in a scientific manner. It is true that the workers were few, but the results of their labours have been fraught with untold blessings to humanity. Foremost amongst these pioneers of sanitary science we find the honoured names of Captain Cook, John Howard, and the immortal Dr. Jenner; and now let us glance briefly at the good work which they accomplished.

Captain Cook's name is associated with the suppression of the once prevalent disease—scurvy; a disease which, up to the latter half of the eighteenth century, decimated our armies and fleets, and often proved terribly fatal amongst the civil population. It is a disease easily recognised and well defined; fostered, as many other diseases are, by insanitary conditions; but its real cause is a diet from which vegetables and fruits have been excluded, and therefore its prevention or cure depends upon a proper supply of vegetable food or vegetable juices. It is true that all this had been known or surmised long anterior to the period in question; but it was reserved for Captain Cook, in his first voyage of discovery round the world, from 1772 to 1775, to prove beyond a doubt that the disease could be banished from every ship's crew, and that it could be entirely eradicated on land and sea. Hitherto it had been a cause of great mortality amongst

seamen; and, to quote one instance out of many, in Anson's famous expedition some thirty years previous to that of Captain Cook, out of a total number of 900 hands 600 died before the expedition returned, and chiefly from scurvy. During Captain Cook's three years' voyage, on the other hand, there were only four deaths, namely, three from accident and one from consumption, out of a total number of 118 men. Captain Cook thus earned for himself a foremost place amongst the sanitary reformers of the eighteenth century; but the nation took years to learn the lesson which he taught, and many more lives had to be sacrificed before it became compulsory that lime-juice should form a part of the commissariat of every sea-going vessel. Scurvy, too, may now be reckoned among the diseases of the past, although it occasionally reappears, but only through blamable neglect or some other mishap.

The next great reformer deserving of special notice was the great and good John Howard. His name, as every one knows, is associated with the prevention of a fatal disease, then known as the jail-fever, which was constantly breaking out in prisons all over the country, had often invaded our courts of law, and made several assizes memorable as the Black Assizes, and which was continually spreading by means of infection, through the agency of discharged prisoners and debtors, amongst all classes of the community. The disease has long since been recognised to be the same as typhus fever, and John Howard lived the life of an apostle and died a martyr in proving that it is a disease which is essentially due to filth and overcrowding. Without enlarging on the incidents of his self-sacrificing labours, the outcome of them is simply this—that for years back the prisons of this country have been proved by the most rigid statistics to be far healthier than our homes, and that so-called pre-

ventable disease of any kind is of such rare occurrence within their walls, that when any isolated cases do appear they at once give rise to surprise, and are sure to call for inquiry.

The next great sanitary triumph of the eighteenth century calling for special notice was the discovery of vaccination. That most hideous and terribly fatal disease, smallpox, had long been a terror and scourge to all classes of the community here and abroad, and after the disappearance of the Plague became the severest epidemic of the country. The introduction of the practice of inoculation at the instance of Lady Mary Wortley Montagu, the wife of the English Ambassador at Constantinople, which took place somewhere about the year 1720, while it modified the severity of the disease, assisted rather than otherwise its spread. But whether this was so or not, we find from the bills of mortality of the time that during the ten years 1771 to 1781 smallpox was the cause of 100 out of every 1000 deaths in London, and there is reason to believe it was quite as fatal in other parts of the country. The practice of vaccination, Jenner's grand discovery, was commenced in the year 1796, and although it was several years afterwards before it became general, its value as a preventive measure was not long in declaring itself in a steadily declining mortality. Thus, according to well-authenticated returns, while the mortality was 88 per 1000 deaths in the last ten years of the eighteenth century, it has fallen progressively from 64 to 11 per 1000 deaths during the first six decades of the present century. And if we have still recurrent outbreaks of the disease, it is because there are thousands of people living at the present day who never have been protected by vaccination, and many thousands more who have been imperfectly vaccinated. For it should be remembered that it was not till 1840

that we had any vaccination laws at all; not till 1853 that vaccination was provided gratuitously for the poor; and not till 1867 that vaccination was made compulsory amongst children generally. We may therefore expect occasional outbreaks, though of constantly decreasing severity, for years to come; but that the disease can and will be finally eradicated, the belief is as deep-rooted and strong in the minds of medical men and of the educated public of the present day as it was in the stout brave heart of Edward Jenner.

In addition to these great sanitary triumphs of the eighteenth century there were others, such as improvements in ventilation and better house accommodation, which were also contributing their share in lessening the general death-rate, and especially in the reduction of fevers of all kinds. Diseases amongst infants and young children were much less fatal at the close than at the beginning of the century, while the labours of John Howard were beginning to tell on the home habits of the people, as they had already told on the vast improvement which had been effected in the sanitary condition of prisons and jails. The health of our soldiers and sailors was much better cared for, and the sickness and mortality greatly reduced. Altogether the progress made in the actual prevention of disease was very considerable; and accordingly we find from the bills of mortality that the death-rate of the city of London, which in the seventeenth century was over 80 per 1000, had been reduced to 50 per 1000, and for some years back it has averaged only a little over 20 per 1000.

Coming now to the beginning of the present century, we find the country engaged in that long fierce struggle with France which culminated in the victory of Waterloo; yet, in spite of the constant drain in men and money, the population kept steadily increasing and the public health

slowly improving. But outside London there were no large towns teeming with overgrown populations—none contained so many as 100,000 inhabitants, and only five exceeded 50,000. By and by, however, there came a sudden and unprecedented change in the social history of the country. The discovery of steam-power opened up new sources of industry of almost unlimited extent and variety. Commerce flourished as it had never flourished before; wealth accumulated; work became plentiful; living became easier; early marriages were encouraged; and the rapid increase of population begun then has continued ever since. The population of England and Wales, which, in round numbers, was only ten millions in 1810, had increased to over fifteen millions in 1838; and at the present day it amounts to over twenty-nine millions. And this enormous increase, it should be remembered, has taken place almost exclusively in already populous towns, or at centres of industry which speedily became populous. But under what conditions? For the most part in the dust and din of factories; the vitiated air of mines; the stifling atmosphere of workshops; the bustle of busy warehouses; and when the day's work was done, in overcrowded houses or underground cellars, heaped together in filthy, narrow, and unventilated streets or reeking back slums. Even in the construction of better class houses the veriest rudiments of sanitation were neglected, because they were still but little understood and less appreciated. Instead of municipal control there was general apathy. Sewers had to be constructed, but they were of the worst possible description, uneven, leaky, unventilated, and incapable of being flushed, while the house drains leading into them were quite as faulty and imperfect. Scavenging was neglected, filth accumulated everywhere, cess-pits multiplied, and wells became polluted. But why fill up the disgusting details of the

picture? The mischief was done, and in spite of recent improvements and legislative enactments, it will take years of steady, earnest, sanitary work, and millions of money, to undo it. The money, no doubt, will be forthcoming, and the cleansing of the Augean stables may be accomplished in time; but the squalor, the misery, the disease, the physical deterioration, and the moral degradation engendered, have imposed a load of vitiated heritage which will tell on generations yet unborn, and which at the present day is crushing thousands of children into an early grave.

Meanwhile the Legislature had done nothing, or next to nothing, to mitigate the terrible evils which were fast accumulating. With the exception of the Factory Act of 1833, and the Poor Law Amendment Act of the following year, no public measures of general importance had been attempted, and even these were haphazard and tentative. It is true that here and there local Acts had been applied for and granted by Parliament to empower town authorities to provide water-supply and drainage, but it was not till those wonderful series of returns of the Registrar-General, and the masterly reports of the late lamented Dr. Farr, began to be published, that public attention became thoroughly aroused. At last, thanks to the incessant labours of the late Sir Edwin Chadwick, Dr. Farr, Dr. Southwood Smith, Dr. Guy, and other pioneers of sanitary progress, the Health of Towns Commission was appointed, and their first report appeared in 1844,—a report in which the relations of cause and effect, as applied to disease, were made so glaring and manifest, that among the intelligent portions of the community there arose a loud cry for legislative interference. Things are still bad enough in the present day, but few can form any adequate conception of the deplorable sanitary condition of the country when that report was published. From

every large town to which the long list of queries was sent, there came, with but little variation, the same terrible series of replies—bad drainage, polluted water, unhealthy houses, overcrowding, filth everywhere; and, as a consequence, an excessive death-rate, with fever and filth-diseases of every description adding enormously to the death-roll. But so powerful were vested interests, and so strong the opposition to interfere with the liberty of the subject or of corporate bodies, that it was not till the country was threatened with a second visitation of cholera as severe as the epidemic of 1831, that Parliament became alarmed and passed the Public Health Act of 1848. Under this Act the General Board of Health was constituted, with a staff of inspectors who were empowered to hold public inquiries and report on the sanitary condition of towns which, according to the returns of the Registrar-General, showed an excessive rate of mortality. The Act itself was eventually adopted or enforced in a great many towns throughout the country; but as it was of a permissive nature, like the great majority of the sanitary Acts which followed it, the beneficial results which might have been expected to accrue from it were long in appearing, and were by no means general. Nevertheless, it originated an era of active sanitary improvement in most of our large towns, and it merits special notice as the first outspoken recognition on the part of the Legislature that the health of the State concerns the statesman. By enabling town authorities to borrow money and spread the expense of public works over a number of years, it removed one of the greatest obstacles to sanitation, and, as a consequence, extensive schemes of sewerage and water-supply were soon undertaken in many parts of the country. But, unfortunately, the engineers of those days largely shared the general ignorance of sanitary principles which then prevailed. Sewers were badly constructed, insufficiently ventilated,

and unflushed; many of them, in fact, were elongated cess-pools, and the sewage itself, collected at one or more outfalls, was discharged into the nearest stream, thereby creating a general befoulment of our rivers, which, in spite of numerous injunctions, became so serious as to call for a special Act, which was passed in 1876 under the title of the Rivers Pollution Act.

Among other Acts which followed the Public Health Act of 1848 may be mentioned the Common Lodging-Houses Act of 1851, the Labouring Classes Lodging-Houses Act of the following year, the Metropolis Management Act of 1855, and the Nuisances Removal Act and the Diseases Prevention Act, both of the same year. But during the interim the nation had been learning another terrible lesson in sanitation. The horrors of the Crimean war, engendered by a faulty commissariat, an utter neglect of scavenging and cleanliness, and an incredible disregard of the most rudimentary laws of health, at last aroused and excited the public mind to the point of indignation, and so in 1857 was instituted the Royal Commission on the Health of the Army. Their report, which is still of the greatest value, was soon followed by the reports of the Barrack and Hospital Commission, and of the Commission on the Health of the Army in India, all of which demonstrated in the most complete manner that the sick-rate and death-rate of the army were culpably excessive; while the adoption of their recommendations, under the able teaching of the late lamented Dr. Parkes, afforded such conclusive proofs of the grand policy of prevention, that a stimulus to sanitary reform began to permeate the more intelligent classes among the general community which has continued to increase ever since.

The powers of the General Board of Health were transferred by Act of Parliament to the Privy Council in 1858, and in the same year the Local Government Board

Act was passed, which consolidated to some extent the previous Sanitary Acts which were in force. The appointment of Mr., now Sir John, Simon as medical officer to the Privy Council, with his able staff of medical inspectors, inaugurated a new era in civil life. The material causes of disease were investigated with a minuteness and completeness of detail which could not fail to influence the most sceptical, and the series of reports in which these investigations are embodied and commented on have become the classics of sanitary literature. To any one who takes the trouble to read these reports, it becomes at once apparent that whatever of purely beneficial sanitary legislation which has subsequently come into force has all along been largely indebted to Mr. Simon's foresight and advocacy, based on the inquiries of such able coadjutors as Seaton, Greenhow, Buchanan, Hunter, Thorne, Netten Radcliffe, Ballard, and others. Many of these inquiries will be specially alluded to in various parts of this work, but this brief historical sketch would be incomplete without referring to two discoveries in sanitary science which have already resulted in a vast amount of good, and are destined to be of still greater benefit to the nation. I allude to Dr. Snow's researches with regard to the etiology of cholera (see Chap. IX.) and the differentiation between typhus and typhoid fever as regards causation and symptoms, and this last deserves special notice.

About the year 1848, when fever was plentiful enough in all our large towns, and did not spare country villages, the late Dr. Stewart, so well known for his contributions to sanitary literature, Sir William Jenner, and a few other earnest workers in hospital wards, began to observe that among the numerous cases of so-called typhus which came under their care there were many which presented symptoms of a more or less uniform character, but

differing in many respects from those which characterised typhus fever. These symptoms soon came to be recognised as those of typhoid or enteric fever, and subsequent inquiries have so clearly established the causes and mode of propagation of the fever that it is now regarded as a disease which is entirely preventable, and one which we have every reason to believe will eventually be as completely banished from our midst as the ague, which was once so common and now so rare. But it was urged by many, when this disease came to be talked about and written about, and was frequently found to be due to the entrance of sewer-air into houses, that in sewering a town public authorities only increased the danger, and that the money expended was worse than wasted. It is true that there was some show of foundation for this belief, but it has long since been made clear that any outbreaks of the disease which have been traced to sewer emanations were due not to the system itself, but to faulty sanitary engineering. Indeed, in the celebrated report of Dr. Buchanan, who was the inspector appointed to visit a large number of towns and make special inquiry into this subject, there was no point more clearly established than the remarkable reduction which has taken place in almost all the towns where a system of sewerage has been carried out. (See Chap. XII.)

Without referring to other important inquiries, such as those relating to unwholesome trades and occupations, food-adulterations, polluted water-supply, overcrowding and unhealthy house-accommodation, milk-contamination, and the widespread agency of filth in the causation of disease, we may note in passing the principal legislative measures which have recently been enacted to cope with these evils. And among these may be mentioned the Adulteration of Food and Drink Act of 1860; Amendments of the Factory Acts; the Sanitary Act of 1866;

the Local Government Board Act of 1871, which vested in one central board the powers previously exercised by the Poor Law Board and the Privy Council; and the Public Health Act of 1872. This last Act divided the country into urban and rural sanitary districts, and necessitated the appointment of medical officers of health and sanitary inspectors; while the Adulteration of Food Act, which was passed in the same year, authorised the appointment of public analysts. Then followed the Public Health Act of 1875, which consolidated the previously existing sanitary Acts; and in the same year were passed an amended Adulteration Bill, and the Artisans' and Labourers' Dwellings Act, intended to sweep away the rookeries in our large towns. The Rivers Pollution Act followed in 1876, the Canal Boats Act in 1877, the Public Health (Water) Act in 1878, while several other Acts have since been passed of special importance, namely, the Local Government Act of 1888, the Infectious Diseases (Notification) Act, 1889, and the Housing of the Working Classes Act. Reserving the consideration of the strictly medical aspects of these various Acts for a future chapter, it may be remarked in passing that, partly owing to the permissive nature of sanitary legislation, partly to the conflicting opinions and want of harmony which it is well known for a long time hampered the policy of the Local Government Board, and partly to the supineness of Local Authorities and their aversion to centralisation and Governmental interference, sanitary reform, in spite of all the obligations which the Legislature has imposed, and the measures to carry them out which it has provided, remains, comparatively speaking, at a standstill in many parts of the country. It is true that in numerous other localities there is abundant evidence of sound sanitary progress, but so long as the Public Health Service is allowed to continue in its

present chaotic condition, so long will there be loopholes for the evasion of duty on the part of sanitary authorities, and inducements to remissness on the part of their officers.

This, however, by the way. Let us now consider for a moment the vast amount of preventable disease with which sanitary science and sanitary legislation had to combat at the date of the passing of the Public Health Act, 1872. It was then estimated by Mr. Simon "That the deaths which occur in this country are fully a third more numerous than they would be if our existing knowledge of the chief causes of diseases were reasonably well applied throughout the country; that of deaths, which in this sense may be called preventable, the average yearly number in England and Wales is about 120,000; and that of the 120,000 cases of preventable suffering which thus in every year attain their final place in the death-register, each unit represents a larger or smaller group of other cases in which preventable disease, not ending in death, though often of far-reaching ill effects on life, has been suffered. And while these vast quantities of needless animal suffering, if regarded merely as such, would be matter for indignant human protest, it further has to be remembered, as of legislative concern, that the physical strength of a people is an essential and main factor of national prosperity; that disease, so far as it affects the workers of the population, is in direct antagonism to industry; and that disease which affects the growing and reproductive parts of a population must also in part be regarded as tending to deterioration of the race."

That this estimate of the number of preventable deaths which occurred annually throughout the country up to the passing of the Public Health Act, 1872, was by no means excessive has received ample verification in

the reports of the Registrar-General, and notably in the report for the year 1881. Sanitary supervision, imperfect though it was, had then been in operation for a decade. The average annual death-rate for the immediately preceding ten years (1862-71) had been 22·6 per 1000, and there was no indication whatsoever of any tendency of the death-rate to fall lower. Indeed, in 1871, the death-rate was exactly the average, namely, 22·6. But coincidently with the passing of the Public Health Act the rate began to fall, and continued to fall with almost unbroken regularity until in 1881 it was only 18·9. If, then, the death-rate in 1881 had been only equal to the average rate preceding the Public Health Act, 1872, there would have died, according to the Registrar-General, in the course of that one year alone, at least 92,000 persons who, as it was, survived, and this saving of life he frankly stated was "the direct product of the money and labour expended in sanitary improvements."

But this saving of life is still further augmented by the lowered death-rate of more recent years; for, in his preliminary report for 1889, the Registrar-General estimates that more than 600,000 persons in England and Wales were alive at the end of that year whose deaths would have been recorded during the nine years 1881-89 had the rate of mortality equalled that which prevailed during the ten years 1871-80. Or, if we compare the death-rate in 1889, namely, 17·9, with the death-rate which prevailed previous to 1871, namely, 22·6, we find that the actual saving of life indicated by this difference, instead of being 120,000 persons, as estimated by Sir John Simon, certainly exceeds 125,000 even when every allowance is made for the correction necessitated by a lowered birth-rate.

This continued lowering of the general death-rate,

coincident with the operation of the Public Health Acts, 1872 and 1875, is shown in the following table:—

	Years.	Mean Annual Death-rate per 1000.
Public Health Act, 1872 .	Ten years, 1862-71	22·6
Public Health Act, 1875 .	Four years, 1872-75	21·8
	Five years, 1876-80	20·79
	Five years, 1881-85	19·30
	1886	19·28
	1887	18·79
	1888	17·83
	1889	17·9

Apart, however, from the reduction of the general death-rate, it is still more satisfactory to find that the mean annual death-rate from the seven principal zymotic diseases, which had been 4·11 and 3·36 per 1000 respectively in the two decades 1861-70 and 1871-80, did not exceed 2·40 in the first five years of the current decennium, while the death-rate from fever alone, during the same period, did not exceed 0·27 per 1000, whereas in the two previous decades it was equal to 0·89 and 0·49 respectively. This remarkable reduction in the death-rate from fever, mostly enteric, affords the strongest possible evidence of the beneficial results which follow in the wake of improved sanitation. Although all this is very gratifying, the wide differences which are exhibited in the returns of the Registrar-General as regards the rates of mortality of different towns and districts prove beyond doubt that influences inimical to life continue to prevail to a far greater extent in some parts of the country than in others, while a closer analysis of the death-register demonstrates still more clearly that this excess of mortality is for the most part due to diseases which in other ways are known to

be preventable, and which detailed medical inspections in various localities have proved to be dependent upon causes which are not only removable, but whose very existence constitutes an offence against sanitary law. These causes have been grouped by Sir John Simon into two great classes, namely, local conditions of filth and nuisance polluting air and water, and reckless disseminations of contagion; and as regards both these wide fields of disease-causation, the various sanitary enactments which have been passed from time to time have conferred extensive powers on sanitary authorities throughout the country to remove the former and see that preventive checks are fully and fairly carried out with regard to the latter.

But in order to carry on this combat against preventable disease to a successful issue, we want a thoroughly organised Public Health Service, with efficiently trained health officers who should be free from the trammels of general practice, and competent sanitary inspectors, all of them holding permanent appointments under the control of the Local Government Board and the newly-constituted County Councils. We also want hospital accommodation for the isolation of cases of infectious disease, not only in towns, but to be available for the more scattered populations of rural districts. We want a wholesale demolition and reconstruction of the miserable homes of multitudes of the working classes; and we want, moreover, what is still very hard to get, the active and intelligent co-operation of the people themselves, not only in safe-guarding against filth and its consequences, but in checking the spread of dangerous infectious disease.

CHAPTER II.—FOOD

SECTION I.—FUNCTIONS AND CONSTITUENTS OF FOOD

WITHOUT entering into a discussion of the various chemico-physical changes which food undergoes in the living body, it may be broadly asserted that its ultimate destiny is the development of heat and other modes of motion, which together constitute the physiological phenomena of animal life. The potential energy with which the food is stored becomes converted into actual or dynamic energy, and is manifested in the body as heat, constructive power, nervo-muscular action, mechanical motion, and the like. But as food also supplies the materials which are requisite for the development and maintenance of the living fabric, as well as for the display of its various kinds of active energy, it may be inferred that inorganic and organic substances are both necessary. The organic alone are oxidisable, or capable of generating force; while the inorganic, though not oxidisable, are essential to the metamorphosis of organic matter which takes place in the animal economy.

The organic constituents of food are generally divided into nitrogenous, fatty, and saccharine compounds; and the inorganic into water and saline matters. Both classes of constituents are present in all ordinary articles of diet, whether they be derived from the animal or vegetable kingdom.

1. *Functions of the Nitrogenous Constituents or*

Albuminates.—The nitrogenous constituents consist of albumen in its various forms, fibrin, syntonin or muscle-fibrine, casein, gluten, legumin, and other allied substances, such as gelatine and ossein. Their chemical composition is remarkably uniform, and, as they seem all capable of being reduced by the digestive process to a like condition, they can replace each other in nutrition, whether they are derived from animal or vegetable foods.

Up to a comparatively recent period it was believed that nitrogenous constituents must first be converted into tissue before their dynamical energy can be elicited; in other words, that muscular force is entirely dependent on the metamorphosis of muscular tissue, and that urea, being the product of the change, ought to be regarded as a measure of the force. This was the doctrine taught by the late Professor Liebig, and it was generally accepted by physiologists until Drs. Fick and Wislicenus of Zurich published their famous experiments connected with their ascent of the Faulhorn. While these experiments proved that a non-nitrogenous diet will sustain the body during severe exercise for a short period, and without any notable increase in the amount of urea, the still more recent researches of Dr. Pavoy in the case of Mr. Weston, so well known for his pedestrian feats, appear to indicate that at the commencement of a prolonged muscular effort, the nitrogen excreted is considerably increased, and that subsequently it will vary pretty much according to the amount contained in the food consumed from day to day.

Judging from these and other experiments, it would therefore appear that, although the main functions of the nitrogenous constituents of food are the construction and repair of the tissues, and the formation of the digestive and other fluids of the body, they exercise other important functions of a regulative and dynamic nature not well defined. There is no doubt that a certain portion of them

is directly decomposed in the blood, and so far they contribute to the maintenance of animal heat and the development of dynamic energy; but the experiments of Pettenkofer and Voit also tend to show that the nitrogenous substances composing the tissues determine the oxidation of the other constituents, or, in other words, that no manifestation of force is possible without their participation in the process.

2. *Functions of the Fatty Constituents.*—All ordinary fats may be regarded as combinations of glycerine with fatty acids, such as oleic, stearic, and palmitic acid. In the process of digestion they are emulsified by the pancreatic juice and bile, and are thus rendered capable of absorption by the lacteal vessels, while a small portion is no doubt saponified. The fact that food containing a large proportion of fatty ingredients is invariably used by the inhabitants of cold countries, indicates that these constituents play an important part in the maintenance of animal heat. Indeed, it has been proved by experiment that the respiratory or heat-producing powers of fat are twice and a half as great as those of the other carbohydrates, as starch or sugar. Fat also takes an active share in the conversion of food into tissue, and aids the removal of effete products from the system. The experiments already alluded to likewise show that its oxidation in the blood generates to a great extent the force which is rendered apparent in locomotion or manual labour. Further, its distribution in the tissues gives rotundity to the form, serves to retain animal heat by its non-conducting properties, and greatly facilitates the working of the various parts of the living machine by lessening friction and preventing jarring by its elasticity.

3. *Functions of the Saccharine Constituents or Carbohydrates.*—These constituents comprise cane-sugar, glucose, sugar of milk, and starch. In the process of digestion

these substances are converted into grape-sugar, which is taken up by the blood and carried by the portal vein to the liver, where it is deposited as glycogen, and subsequently supplied to the system as required, where it becomes oxidised and converted into water and carbonic acid. Like the fatty constituents, the carbo-hydrates are directly subservient to the maintenance of animal heat and the production of animal force. They are capable of being converted into fat in the system, and are largely concerned in carrying on the digestion of nitrogenous substances, and in maintaining the proper reaction of the various bodily fluids.

4. *Functions of Water and Saline Matters.*—The principal functions of water in the animal economy are—the solution and conveyance of food to different parts of the system, the removal of effete products, the lubrication of the tissues, the equalising of the body temperature by evaporation, and the regulation of the chemical changes which take place in the processes of nutrition and decay. Saline matters, on the other hand, are the chief media for the transference of the organic constituents throughout the body. They are largely concerned in the consolidation of the tissues, and are supposed to convert unabsorbable colloids into highly diffusive crystalloids.

The functions of what are called the accessories of food, such as beverages, stimulants, etc., are still matters of speculation. Vegetable acids prevent impoverishment of the blood, and are the best correctives against scurvy.

That all these four classes of constituents should be present in a well-arranged dietetic scheme is alike taught by experience and proved by experiment. No single class is capable of sustaining life by itself, although it is certain that health can be maintained for some time on a diet consisting of the nitrogenous, fatty, and saline matters.

It has further to be noted that the ordinary articles

of food represented in common dietaries contain on the average 50 to 60 per cent of water, and in addition from 50 to 80 oz. are daily taken into the system, the amount varying according to the nature of the work, the temperature of the air, and the quantity of stimulants which may be consumed from day to day.

Section II.—Food and Work

As the phenomena of nutrition depend mainly on the chemical interchanges of nitrogen and carbon with oxygen, different articles of diet have been estimated according to the amount of nitrogen and carbon which they contain. But inasmuch as the actual value of the carbonaceous compounds in fatty constituents is nearly twice as great as that of the saccharine constituents, it is evident that, in framing a table of alimentary equivalents, the amount of carbon must be stated as having the same nutritive value throughout. In the following table, therefore, which is taken from the late Dr. Letheby's valuable work on *Food*, the amount of carbonaceous matters in the different articles of diet is estimated as starch:—

	Grs. per pound.			Grs. per pound.	
	Carbon.	Nitrogen.		Carbon.	Nitrogen.
Split peas	2699	248	Sugar	2955	—
Indian meal	3016	120	Treacle	2395	—
Barley meal	2563	68	Buttermilk	387	44
Rye meal	2693	86	Whey	154	13
Seconds flour	2700	116	Skimmed milk	438	43
Oatmeal	2831	136	New milk	599	44
Bakers' bread	1975	88	Skim cheese	1947	483
Pearl barley	2660	91	Cheddar cheese	3344	306
Rice	2732	68	Bullock's liver	934	204
Potatoes	769	22	Mutton	1900	189
Turnips	263	13	Beef	1854	184
Green vegetables	420	14	Fat pork	4113	106
Carrots	508	14	Dry bacon	5987	95
Parsnips	554	12	Green bacon	5426	76

	GRS. PER POUND. Carbon.	Nitrogen.		GRS. PER POUND. Carbon.	Nitrogen.
White fish .	871	195	Salt butter .	4585	—
Red herrings .	1435	217	Fresh butter .	6456	—
Dripping . .	5456	—	Cocoa . .	3934	140
Suet . .	4710	—	Beer and porter	274	1
Lard . .	4819	—			

As this table contains almost all the articles which are likely to be met with in a common dietary, it becomes no difficult matter to calculate the total amount of carbon and nitrogen which any such dietary yields, and to compare the results with other dietaries that have been calculated in the same way. It is necessary to add that the nutritive equivalents apply to articles in their uncooked state, and that the meat is boned. On the average about 20 per cent should be allowed for bone, and 20 to 30 per cent more is lost in cooking.

In the subjoined table are given the analyses of different articles of diet in common use, by various analysts, to show the relative proportion of the several constituents :—

Articles.	In 100 Parts.				
	Water.	Albuminates.	Fats.	Carbohydrates.	Salts.
Beef and mutton as ordinarily supplied .	75	15	8·4	—	1·6
Bacon . . .	15	8·8	73·3	—	2·9
Salt beef . . .	49·1	29·6	0·2	—	21·1
White fish . . .	78	18·1	2·9	—	1
Poultry . . .	74	21	3·8	—	1.2
Flour	15	11	2	70·3	1·7
Wheaten bread . .	40	8	1·5	49·2	1·3
Rice	10	5	0·8	83·2	0·5
Oatmeal . . .	15	12·6	5·6	63	3
Peas (dry) . . .	15	22	2	53	2·4
Potatoes . . .	74	2	0·16	21	1
Cabbage . . .	91	0·2	0·5	5·8	0·7
Eggs	73·5	13·5	11·6	—	1
Cheese . . .	36·8	33·5	24·3	—	5·4
Milk	86·7	4	3·7	5	0·6
Butter . . .	6	0·3	91	—	2·7
Sugar. . . .	3	—	—	96·5	0·5

In using this table the dry albuminates, fats, and carbo-hydrates may be calculated in grains of nitrogen and carbon by first ascertaining the amount of these substances in ounces in any given dietary or meal, and then employing the following factors :—1 oz. of albuminates contains 70 grs. of nitrogen and 212 grs. of carbon; 1 oz. of fat contains 336 grs. of carbon; and 1 oz. of carbo-hydrates contains about 190 grs. of carbon.

The separate amounts and relative proportions of the several classes of constituents required in what is called a subsistence diet, a diet for ordinary labour, and a diet for laborious work, required for a healthy male adult of average size and weight (150 lbs.), based on the researches of Moleschott, Playfair, Pettenkofer, Parkes, and others, is approximately represented as follows :—

Water-free Substances given daily.	Subsistence.	Ordinary Labour.	Active Labour.
	ounces avoir.	ounces avoir.	ounces avoir.
Albuminates .	2·0	4·5	6·5
Fats . . .	0·5	3·5	4·0
Carbo-hydrates .	12·0	14·0	17·0
Salts . . .	0·5	1·0	1·3
Total water-free food	15·0	23·0	28·8

Expressed in grains of nitrogen and carbon the above data yield, for ordinary labour, 315 grs. and 4790 grs. respectively. According to the late Dr. Edward Smith the average mean of the dietaries of low-fed operatives amounts to 214 grs. of nitrogen and 4881 grs. of carbon daily, while Sir Lyon Playfair found that well-fed operatives consumed an amount of food representing an average daily mean of 400 grs. of nitrogen and 5837 of carbon. On the other hand, the late Dr. Parkes, while experimenting on four healthy men of average height and weight, and employed at ordinary

labour, ascertained that perfect health and uniform weight were maintained on a diet containing 293 to 305 grs. of nitrogen. Generally speaking, the proportion of nitrogen to carbon in all well-arranged dietaries should be 1 to 15.

As an addendum to these data, and by way of contrast, I may here give some particulars with reference to the dietaries of the convicts confined in English prisons. In the hard-labour prisons, where the great majority of the prisoners are employed at active outdoor work, there are two scales of diet—viz. the light-labour diet, and the full-labour diet. When medical officer to the Portsmouth Convict Prison, I carefully calculated the nutritive values of the various articles of food contained in these diets, according to the equivalents given in a preceding table, and the results were as follows:—

	Daily Average.	
	Carbon, Grs.	Nitrogen, Grs.
Light-labour diet	4651	224
Full-labour diet	5289	255

Extended observation proved that the full-labour diet was inadequate to sustain prisoners employed at hard navvy work for any length of time, and their average loss of weight was so great that they had constantly to be shifted to lighter labour to enable them to recruit.

The potential energy derivable by oxidation from different articles of food is expressed as so many foot-tons per ounce consumed, or so many tons raised to a height of one foot. Thus 1 oz. of dry albuminate is supposed to yield 173 foot-tons, 1 oz. of fat 378 foot-tons, and 1 oz. of carbo-hydrates 135 foot-tons. According to these figures, the average daily diet for ordinary work is capable of yielding about 4000 foot-tons. A large proportion of this potential energy, however, is expended in respiration, circulation, and other internal work. In the first place, the

work done by the heart, according to Professor Haughton's experiments, is estimated at 260 foot-tons, while the animal heat absorbs from 2000 to 2500 foot-tons in addition, or altogether about 2600 foot-tons may be set down as the amount required for the internal work of the body. Then it has been calculated by Helmholtz that, out of the potential energy, over and above what is required for the internal work of the body, only about one-fifth can be obtained as productive work. For an ordinary day's work, therefore, of 300 foot-tons, about 1500 foot-tons should be supplied by the diet in addition to the amount required for the internal work of the body, or altogether 4100 foot-tons. A strong man can do a day's work varying from 300 to 500 foot-tons or even more. A man weighing 150 lbs., and walking at the rate of three miles an hour on the flat, does an amount of work equivalent to climbing vertically one-twentieth of the distance travelled. Thus, a man walking a distance of twenty miles on a flat at the rate of three miles an hour does as much work as if he raised his body through a mile in direct altitude, or about 350 foot-tons. A hard day's work is equivalent to about 450 foot-tons, and an extremely hard day's work to 600 foot-tons.

All these calculations, however, are to a certain extent problematical, and though tables of potential energy may give broad indications of the sufficiency or insufficiency of a dietary for certain kinds of work, they cannot fix dietetic value.

Section III.—Construction of Dietaries

By reference to the numerous data already given, it will not only be easy to calculate the nutritive value of any given dietary, but a reliable opinion may be formed as to its suitability as well as sufficiency under specified

circumstances. It now remains to point out the more important principles which ought always to be kept in view in the construction of dietaries; and apart from the influence of work, which has already been considered, they may be briefly summarised as follows:—

1. *Influence of Sex.*—In the case of in-door operatives, the dietaries of women should be about one-tenth less than those of men.

2. *Influence of Age.*—Up to nine years of age a child should be dieted chiefly on milk and farinaceous substances. At ten years of age it will require half as much nutriment as a woman; and at fourteen quite as much as a woman. Young men who have not reached their full growth, but who are doing the same amount of work as adult men, require more food than the latter.

3. *Selection of Food.*—This embraces a variety of considerations, such as—

(1.) *The relative proportions of proximate constituents.* The mean obtained from numerous experiments by Moleschott, Pettenkofer, Voit, and Ranke is as follows:—albuminates, 100; fat, 82; carbo-hydrates, 272; and salts, 23. Whether the diet be mixed or purely vegetable the same proportions should hold good, and the results of experience prove that they are substantially correct. For example, articles of food which are deficient in one class of constituents are invariably associated with others which contain an excess of them. Thus we have butter, or milk, or cheese, with bread; bacon with veal, liver, and fowl; melted butter or oil with fish, and so on. Such combinations are also of great service in aiding the digestibility of food. For reasons to be afterwards stated, every dietary should contain fresh vegetables.

(2.) *Variety of Food.*—But even when the proper proportions of constituents are provided for in a dietary,

it is further necessary that certain articles belonging to the same class be varied from day to day, otherwise the appetite cloys. Beef should alternate with mutton, for example; or variety may be secured by different modes of cooking the same article. Indeed, it is not too much to say that the art of cookery is a matter of national importance, not only because it renders food palatable, but because the more it is studied and practised the greater is the economy which may be effected. It is chiefly in this respect that beverages, condiments, etc., become such valuable dietetic adjuncts.

As already pointed out, in apportioning rations of meat, 20 per cent must be allowed for bone. The loss in weight by cooking varies from 20 to 30 per cent.

(3.) *Digestibility.*—This also in great measure depends upon the mode of cooking, though it need hardly be said that some foods are much more digestible than others. As a rule, animal foods are digested sooner than vegetable, and the residues which leave the body are smaller in amount.

4. *Number and Distribution of Meals.*—Experience teaches that three meals daily are best suited to the wants of the body. Dr. Edward Smith, in his physiological diet of 4300 grains of carbon and 200 of nitrogen, distributed the amounts as follows:—

	Carbon.	Nitrogen.		Carbonaceous.	Nitrogenous.
	grs.	grs.		oz.	oz.
For Breakfast	1500	70	=	6.62	1·04
For Dinner	1800	90	=	7·85	1·34
For Supper	1000	40	=	4·52	0·59
Total daily	4300	200		18·99	2·97

5. *Climate.*—Other things being equal, carbonaceous substances ought to contain a preponderance of fatty constituents in cold climates, and of starchy or farinaceous in warm climates. This also applies to seasonal variations.

Section IV.—Preserved Foods

1. *Preserved Meat.*—Meat may be preserved in various ways:—by salting, by pickling, by drying in the sun, by boiling the meat in tins which are hermetically sealed at the boiling temperature; and by refrigerating in the raw state. This last process is the most successful, and enormous quantities of excellent fresh meat are now imported in refrigerating chambers on board ship from New Zealand, Australia, and America. Before cooking the meat should be hung up and the moisture which collects on the surface should be wiped off with a clean cloth. Refrigerating chambers would be of immense service as adjuncts to public abattoirs.

Weight for weight, meat preserved in tins is not so nutritious as properly cooked fresh meat, because this process of preservation requires that it should be over-cooked. The great difference in price, however, more than compensates for this disadvantage, and on the score of convenience and economy it deserves to be extensively used. It is best used cold, or warmed and mixed with cooked potatoes and vegetables to form a stew; or it may be minced and warmed.

Among the numerous extracts of meat Liebig's extract is perhaps the best known, but there are several other extracts in the market of almost identical composition. According to Dr. Parkes, Liebig's extract is very restorative, removing all sense of fatigue after great exertion. Its nutritive qualities are inferior to those of ordinary beef-tea, but it can often be taken by an invalid when beef-tea would be rejected; and it has the further advantage of being readily prepared. Brand's essence of meat and Nelson's preparations are also very highly commended, and an extract known as Bovril has recently become very popular as a nutritive and restorative agent.

Soups of various kinds, fish, poultry, game, are also sold in large quantities as preserved foods.

3. *Preserved Vegetables.*—When fresh vegetables cannot be procured in sufficient quantity, dried vegetables should be employed to make up the deficiency. In lieu of potatoes in the early part of summer, preserved potatoes may be used; but as they are apt to pall on the appetite, other substitutes, such as a mess of rice and cabbage, pease-pudding, or haricot beans, should be given on alternate days. Preserved peas, tomatoes, and various kinds of fruit may be obtained for the table all the year round.

4. *Preserved Milk.*—Condensed milk as usually prepared consists of pure milk, or milk sweetened with a little sugar. As one volume of the condensed milk contains the nutritive material of four volumes of fresh milk, it should be diluted with three times its volume of water when used.

Section V.—Diseases which render the Flesh of Animals unfit for Human Food

Perhaps there is no more difficult task which can devolve upon the sanitary official than to have to decide whether the meat which he is called upon to examine comes from a diseased animal, and if so, to determine the nature of the disease. Even the well-trained and experienced veterinary surgeon, when he is called in to decide, is often at fault. And yet it is most important in the interests of the public, that this traffic in diseased meat, which, in spite of inspection is still carried on to a scandalous extent, and, especially when infectious disease is prevalent among animals, should be kept in check. It will be well, therefore, to discuss somewhat in detail the leading symptoms and features of the principal diseases which affect animals whose flesh is used for human food;

but before doing so it will be of advantage to indicate the main points which characterise healthy living animals, and, briefly summarised, they are these:—The animal's coat should be in good condition, the skin supple and free from scabs, pustules, or sores of any kind. The animal itself should be well-fed and able to move about without signs of stiffness or lameness. Its mouth and nostrils should be free from any discharge, and its breath from offensive odour, while the breathing should be easy and noiseless. Its eyes should be bright, and it should give no signs of shivering or being in pain. If an animal has been driven far to market it will often become footsore, but the resulting lameness will easily be accounted for, and need not therefore be regarded with suspicion.

The most prominent among the diseases which render the flesh of animals unfit for human food are—cattle-plague, contagious pleuro-pneumonia, anthrax and anthracoid diseases, foot-and-mouth disease, varioloid disease, tuberculosis, arthritis, measles, puerperal fever, acute rheumatism, actinomycosis, rot in sheep, pig-typhoid, pig-measles, trichiniasis, fowl-cholera, and acute febrile disorders from whatever cause. To those who are desirous of making themselves more fully acquainted with this wide subject I would strongly recommend the perusal of Professor Walley's book on *Meat Inspection*, or Fleming's excellent *Manual on Veterinary Sanitary Science and Police*, from which much of the following information has been collated.

1. *Cattle-plague.*—This disease is highly contagious, but admittedly somewhat difficult to diagnose in its early stages. From the first onset, however, the temperature is variable and rises, the hair becomes dull and erect, the appetite fails, and after a time there is a frequent, dry, short, cough. The mucous membrane becomes red and soon covered with patches, and a glairy discharge sets in

from the eyes, nose, and mouth, and, in cows and heifers, from the vulva. The ears droop, the secretion of tears becomes copious, there is much shivering and ephemeral muscular contraction, and the animal becomes very restless and sometimes delirious. In a short time purging sets in, and in most cases an eruption appears on the inside of the thighs, udder, and loins.

When the animal is killed the whole mucous tract is found to be reddened and congested, extravasations of blood are generally to be detected in the later stages on the intestines and heart, while the inside of the intestines is covered with a blood-coloured glairy fluid. Except in advanced stages of the disease, the flesh is not much changed in appearance, but it does not set well. When the disease is well developed the flesh is dark, flabby, and has a disagreeable smell, and often crackles, owing to infiltration of air into the tissues.

The propriety of using the flesh of animals killed when suffering from this disease has been discussed for more than a century; and no doubt in this country during the epidemic of 1865-66, and in Paris after the siege, there was a regular traffic in meat of this description without any recorded ill effects. Fleming maintains, therefore, that under exceptional circumstances it may be used without any very great precaution, but under the ordinary circumstances of every-day life, the medical officer of health should condemn it without the slightest hesitation. Indeed, under the Contagious Diseases (Animals) Act its destruction is absolutely enjoined.

2. *Contagious Pleuro-pneumonia*, though it sometimes attacks sheep and swine, is more especially a cattle disease. The early symptoms are generally slow and insidious, but from the first there is a rise in the temperature, the appetite becomes less keen, the coat becomes rough and loses its lustre, and eventually a dry,

short cough sets in. Later on the breathing becomes laboured, and in coughing the back is arched, and the head and neck extended. At this stage, or even earlier, auscultation and percussion, more particularly over the lower lobes of the lung, will reveal the true nature of the disease. When the animal is slaughtered the pleuræ or lining membranes of the chest and lungs will be found to be rough and thickened, and covered more or less with fibrinous exudation, while the chest cavity is often distended with a large amount of semi-purulent fluid. In the early stages the lungs present a grayish appearance with red or purple patches, and they become less spongy. Later on they are found to be dark and marbled in appearance, resisting and solid on section, and pieces cut off sink readily in water, while their weight is often increased ten or thirty pounds, or more.

The chief characteristic of the flesh is that it usually looks dark and harsh in appearance, the fat yellow tinged, and there is an absence of blood generally. In order to palm the meat off as sound meat, butchers often strip off the lining membrane from the walls of the chest and smear them with fat, but this artifice may be readily detected on examination. In 1880 a very warm discussion was aroused in consequence of the Metropolitan Board of Works sanctioning the sale of the flesh of animals slaughtered for pleuro-pneumonia as fit for human food; and though, no doubt, meat of this description has been eaten in large quantities with apparent immunity, it was urged that in adopting such a course more respect was paid to the views of veterinary surgeons than of medical men. But so far as the duties of medical officers of health are concerned, it will generally be found that, no matter whether the meat is much diseased or not, it is exposed for sale as sound meat, and as it is thus palmed off on the public under a fictitious character, there ought

to be no hesitation in condemning it, especially when the history of the carcase can be fully traced.

When the disease attacks the pig or sheep the same changes will be found in the lungs and on the pleuræ, while the intestines are often inflamed and marked here and there with dark patches.

3. *Anthrax and Anthracoid Diseases.*—From the remotest times these diseases have given rise to wide-spread and most fatal epidemics, not only among domesticated animals, but among many wild animals. The specific contagium is believed to be a characteristic *bacillus*, the *Bacillus anthracis,* and these *bacilli* crowd the blood of the diseased animal to such an enormous extent that as many as eight or ten millions have been estimated to exist in a single drop. Fleming divides these diseases into two classes—the general and localised—the former known as splenic apoplexy or anthrax fever, and the latter as carbuncular or anthracoid erysipelas. Other writers, however, distinguish a third form, called *black-quarter* or *black-leg,* characterised by the swelling and dark-coloured appearance of one of the fore or hind quarters. In anthrax fever the disease generally runs a very brief course, sometimes the animals falling as if shot or slain. In other cases, the animals commence to tremble and stagger, the breathing becomes hurried, the pulse rapid, and there is a bloody discharge from the mouth, nostrils, and other passages. In the early stage of the disease there is usually marked thirst, and during the later stage the temperature falls.

Localised anthrax presents itself in two forms—the erysipelatous and carbuncular. In both varieties there is infiltration into the connective tissue under the skin and between the muscles, but in the latter the exudation is more or less circumscribed in the form of tumours under the skin, mucous membranes, and in the connective tissue.

In both there is extreme venous congestion, and as a consequence hæmorrhagic extravasations are numerous and well-marked. The liver, kidneys, and lungs are congested, often greatly enlarged, and friable. But the most characteristic feature of the disease is the enlargement of the spleen,—the parenchyma of that organ being transformed into a violet or black fluid mass. The flesh is often flabby and dropsical, and rapidly passes into a state of putrefaction; while dropsical effusion may generally be detected between the lobes of fat surrounding the kidneys.

In anthracoid disease of the pig the chief symptoms are thirst, loss of appetite, rigours, hurried respiration, and feverishness. If death does not ensue rapidly, as in the apoplectic form, the snout becomes of a leaden hue, and the ears, belly, and inner surface of the thighs become covered with red patches which deepen in colour. In the later stages of the disease, as in cattle, the temperature falls, the body becomes cold, and there is a mucopurulent discharge from the eyes. The carcase of a pig thus affected is livid, red, or mottled over most of the surface, the spleen is enlarged, and the flesh is sodden and darker in colour, while blood-coloured patches are generally found on the heart and intestines.

Sheep are more liable to the apoplectic form of the disease than other domesticated animals, and it especially attacks those that are well bred. In the majority of cases there are no apparent premonitory symptoms, the animal often falling down while grazing, and dying in convulsions within a few minutes. In other cases, which are not so rapid in their course, it is observed that the sheep is dull, carries its head low, does not eat, appears uneasy, and, if the herd is moving, drops behind. Its breathing is hurried, the pulse is rapid, the conjunctival membrane congested, and the lower lip becomes marked

with patches of a violet hue. When the disease is fully developed, the animal suffers from tremblings, so that it can no longer stand; and there is bloody discharge from the mouth, nostrils, and other passages. Sometimes there is œdema of the neck and flanks; and eventually convulsions set in. External tumours are rarely to be met with in sheep, and then mostly on the head, udder, or inside of thighs. The more common form of the localised disease is a diffused anthracoid erysipelas. In Scotland the splenic apoplexy of sheep is known as *braxy*. The flesh is very dark and often dropsical, and the spleen is increased in weight from two to six ounces.

The uncooked or imperfectly cooked flesh of animals slaughtered for anthrax is extremely dangerous, and numerous widespread and fatal outbreaks of disease in man have been traced to the consumption of food of this description. But if well cooked, it is said that accidents are rare. It need hardly be said, however, that, taking into consideration the great risk, the flesh of all animals slaughtered when suffering from the disease, or even when suspected to be infected, should be condemned.

4. *Foot-and-Mouth Disease.*—This disease is highly infectious, and attacks cattle, sheep, pigs, and other animals. It is characterised by an eruption of small vesicles in the mouth and on the tongue, sometimes extending to the nostrils. It also appears in the cleft and round the top of the hoof; while in cows, ewes, and sows the teats and udders are commonly affected. Dr. Klein, in some researches carried on for the Local Government Board, has discovered crowds of *micrococci* in the vesicles, which he has been able to cultivate, and which, he maintains, is the cause of the disease. They appear in the vesicles in the shape of dumb-bells, or as chains, and by feeding sheep on a mixture which contained

them, even after the twentieth cultivation, he has succeeded in producing the typical disease—viz. vesicles and ulceration of the feet. The vesicles, though small at first, often become large and confluent, and when they burst they leave bare red spots, which sometimes suppurate. Inside the mouth the vesicles burst soon after they are formed, and in cattle the saliva often becomes tinged with blood. When the limbs are affected the coronet becomes red and swollen, and the animal lame. Sometimes the hoof may be loosened or shed. Occasionally, and more particularly in sheep, the mouth and tongue are affected, or the feet may be very slightly affected without the appearance of vesicles. In severe cases there is much fever, prostration, and thirst, while in sucking animals the disease frequently extends to the pharynx, larynx, and small intestines, and is sometimes of such severity as to induce typhoid symptoms. Except in severe cases, the flesh of animals slaughtered cannot be distinguished from the flesh of healthy animals, and may be passed, but the head, udders, and feet should always be rejected. If, however, the disease has been severe, and there are signs of inflammation or abscesses, or if the flesh is flabby, watery, ill-fed, and sets badly, it ought to be condemned.

Somewhat allied to foot-and-mouth disease, and occasionally mistaken for it, is contagious foot-rot of sheep, which is mainly distinguished from the former by the absence of mouth symptoms. It is in reality a chronic inflammation and ulceration of the soft parts of the feet, and it attacks more especially the purest breeds. It is characterised by lameness and suppuration, which often leads to shedding of the hoof. Except in cases when the inflammation extends to the carcase, and induces irritative fever and emaciation, the meat may be passed, provided it sets well, but the feet should always be condemned.

5. *Varioloid Disease.*—This disease in cattle, known as cow-pox, is generally so mild and rare that it only merits passing notice. After slight febrile disturbance, which often passes unnoticed, the udder is observed to be swollen near the teats, and in a few days small hard tumours about the size of a pea or bean appear on the teats and udder. These "pocks" gradually increase in size, and attain their maximum development on the eighth or tenth day, when they become purulent, and a crust forms which becomes detached from the eleventh to the fifteenth day. If used for vaccination, the vaccine matter is collected from the eighth to the tenth day before it becomes purulent, and it is at this stage that the disease is most likely to be conveyed to the hands of milkers. Except in very rare instances, the disease runs a mild course.

The disease as it affects sheep is highly contagious and often extremely fatal. After two or three days of more or less severe febrile disturbance, an eruption, at first resembling flea-bites, appears on the inner aspect of the thighs, chest, and belly, extending over the whole body. Towards the fourth or fifth day the eruption becomes vesicular, and afterwards pustular. The eruption often extends to the mouth and nostrils, and the wool readily comes off. Except in the early stages of the disease, the flesh of slaughtered animals has a disagreeable odour, and even in suspected cases is altogether unfit for human food.

The common and fatal disease, sheep-scab, which is caused by a parasite, known as the *Psoroptes ovis*, usually disfigures the carcase so much that the flesh is not exposed for sale, and if exposed would be found to be flabby and emaciated. In swine the symptoms of variola are not unlike those of sheep-pox, and the eruption runs a similar course. The disease is highly con-

tagious, and the flesh of slaughtered animals ought always to be condemned.

6. *Tuberculosis,* or consumption, more popularly known as *pearl disease* or the *grapes,* is a disease which specially affects cattle, and is most common among cows which are kept fastened up in crowded town cow-houses. The disease is slow and insidious in its onset, and may not be suspected until the animal loses in condition and begins to suffer from cough. The pearls or nodules, small at first, but gradually increasing in size, occur on the inside of the walls of the chest, the surface of the lungs, and, as the disease advances, the lungs themselves become affected, and eventually cavities are formed. On cutting open the nodules they will be found to consist of cheesy-looking matter of the same consistence throughout, or softening towards the centre, and in all tuberculous deposits or discharges Koch's tubercle *bacilli* will be found.

The flesh of animals slaughtered in the early stage of the disease may not present any features differing from those of sound meat, but in the more advanced stage it is pale, flabby, and poorly nourished, and in any case should be condemned. The signs of pleuritic adhesions on the walls of the chest should be carefully looked for, and the glands should be examined.

According to a recent decision by the Sheriff of Glasgow, the flesh of all animals proved to be suffering from tuberculosis should be destroyed as unfit for human food, and though *bacilli* have been rarely discovered in the milk of tuberculous cows, there can be no question that all such milk should be unhesitatingly condemned.

Tuberculosis is also common among pigs, poultry, pigeons, and pheasants, and in respect to these the same rule of condemning as unfit for food should apply. Professor Walley states that the disease in fowls is commonly known as croup or diphtheria.

7. *Arthritis* in cattle is commonly known as "joint-ill" or "joint-felon." The prominent symptoms are lameness and inability to rise, feverishness, and swelling of the joints. The serous fluid which is effused into the joints may subsequently become purulent, and abscesses are occasionally found in other parts. Frequently the meat becomes dropsical and should be condemned.

8. *Puerperal or milk-fever* not unfrequently attacks cows after calving, and if the animal is slaughtered when suffering from the disease the meat is certainly unfit for human food. The signs of recent parturition will be apparent, and the flesh will generally be found to be sodden and congested. If the slaughtering is due to some complication in calving or lambing, and the carcase is frankly submitted for inspection, it may be passed if the meat sets well and does not show any signs of congestion. In malignant parturient fever so common among sheep, the carcase should always be condemned.

9. *Rot in Sheep.*—This disease is the most devastating of all diseases which attack sheep. Its essential cause is the presence in the bile-ducts of the liver of entozoa known as "flukes," small animals shaped like a sole, measuring from about an inch to an inch and a half in length, and when once seen can always be recognised. These flukes attach themselves to the sides of the bile-ducts by means of suckers, and in the later stages of the disease are present in such large numbers that the ducts often become completely blocked up, and even burst, so that the substance of the liver becomes broken down. The prominent symptoms of the disease are dulness, sluggishness, and yellowness of the conjunctivæ; the wool drops off, the animal becomes emaciated, and, as a rule, dropsical. The flesh is found to be thin, watery, and flabby, and the tissues are more or less bile-stained.

When the disease becomes pronounced, the flesh is undoubtedly unfit for human food, but the presence of a few flukes in the liver would not warrant the seizure of a carcase provided the meat looked healthy.

10. *Actinomycosis.*—This disease is produced by a "ray or fission fungus," which in cattle generally attacks the tongue or lower jaw and sometimes leads to septicæmia. When there is distinct evidence of malnutrition and febrile symptoms the flesh should be condemned.

11. *Pig-typhoid or Hog-cholera.*—By some writers this disease is classified as identical with anthracoid disease, and, indeed, the symptoms bear a close resemblance to those already described under that heading. The premonitory symptoms are feverishness, restlessness, and rapidity of breathing, after which an eruption begins to appear on the skin, which may be red and patchy, when the disease is called "red soldier," or of a livid tint, when it is sometimes designated "blue soldier." The redness of the skin generally extends through the fat beneath to the muscular tissues, and the intestines often become marked with extravasations. Butchers, in order to disguise the character of the meat, sometimes rub the edges of the reddened fat with salt, but by scraping with a knife, or making a fresh incision, this attempt at deception may readily be detected. The lungs are generally found to be congested, or in parts more or less solidified by pneumonic exudation. When the skin eruption is well marked, it is seldom that the meat is exposed for sale. The eruption sometimes bears a close resemblance to small-pox, pus being secreted and followed by the formation of crusts. The flesh of all pigs, whether suffering or suspected to be suffering from this disease, should be condemned.

12. *Quinsy,* or "strangles," is a disease which

sometimes attacks pigs. It is characterised by sore throat and swelling in the neck, which may extend into the fore quarters. The premonitory symptoms are laboured breathing, refusal of food, and swelling about the throat, which looks red or livid. The flesh is unfit for human food.

13. *Trichiniasis* or *Trichinosis* is a disease which infests a number of animals, but the chief interest attaching to it is the fact that it is a disease to which pigs are liable, and by eating diseased pork is transmissible to man. The essential cause of the disease is the presence of a parasite known as the *Trichina spiralis* in the muscular tissue of the pig. These parasites are found to exist in three conditions in the animal body—as intestinal, embryonic, or muscular trichinæ. During the period of reproductive or genital activity they inhabit the intestines, and it would appear that in their course of migration they penetrate the intestinal wall, fall into the abdominal cavity, and are discovered earliest in the muscles which enclose the cavity, viz. the diaphragm and abdominal muscles. Other muscles become subsequently infested—the intercostals, muscles of the neck, head, and back, and last of all the muscles of the limbs and tail. In these different regions of the muscular system they continue their development, become at length encysted, and then remain perfectly stationary. Their further development depends upon whether or not the trichinosed flesh is eaten in an uncooked or imperfectly cooked state, when they again pass through similar stages in the newly infested animal, that is to say, breed in the intestines and migrate to the muscular tissues, and in this way they infest man.

In searching for trichinæ in pork the muscles most liable to be infested should be selected, such as the diaphragm, masticatory muscles near their insertion, or

intercostal muscles, and the aid of a powerful pocket-lens or microscope is necessary. But without the microscope the eye may discern a paleness and œdematous condition of the flesh if the trichinæ are very numerous, while the flesh itself presents a speckled appearance. These small white specks are the spherical or oval cysts in which the parasites are coiled up, and sometimes they feel gritty, owing to the presence of carbonate of lime. In order to examine them microscopically, a very thin shaving of the flesh in the direction of the muscular fibrillæ should be placed on a glass slip, and soaked in a solution of liquor potassa (one to eight or ten of water), but for only a few minutes. The section should then be teased out with needles protected by a covering glass, and placed in the field of a microscope with a magnifying power of 50 to 200 diameters. If the capsule is thick and opaque, owing to the presence of carbonate of lime, a drop of weak solution of hydrochloric acid will render it transparent; and should a little fat obstruct the view, a drop of ether or benzin will remove it. The fully-developed trichinæ, in their genital stage, must be looked for in the small intestines, more particularly in the layer of mucus covering the lining membrane of the duodenum. In the migratory stage of the undeveloped trichinæ, and before they become encysted, a high power is necessary for their detection. Swine infested with the disease may not present any noticeable symptoms during life. The flesh should invariably be condemned.

14. *Measles in the Pig.*—This disease, like the preceding, is due to a parasite or entozoon, in the form of a bladder-worm, known as the *Cysticercus cellulosus.* It is much larger than the *Trichina spiralis,* and is developed from the ova of the human tape-worm (*Tænia solium*), which are expelled from the intestine along with the fæces. These ova are swallowed by the pig when it

devours infested fæces, and the embryos which they contain are developed into hydatids. Each embryo is provided with six hooklets, and soon after being introduced into the interior of its host, it commences to penetrate the tissues in its immediate neighbourhood, until it has reached a favourable position, when it assumes the hydatid or bladder form. This it maintains permanently, unless it is transferred by the meat which it infests to the intestinal canal of man, when it develops into the fully matured tape-worm. The cysticercus is contained in an egg-shaped bladder, varying in size from an eighth to three-eighths of an inch in length, and surrounded by fluid. Unlike the cysts of the *Trichina spiralis*, which are embedded in the substance of the muscular fibrillæ, these bladders are found between the muscular fibres, and often on the surface of the muscles. To examine one of these bladders, it should be put on a glass-slip and incised, when, with the aid of a good pocket-lens, the worm will be found curled up in the cavity. It is about one-third of an inch in its longest diameter, or varying from the size of a pea to that of a cherry, and in its retracted state it is somewhat oval or elliptical. In order to examine the head it is necessary to extract it from its cavity or *receptaculum* with fine needles, when it is found to be square-shaped if viewed from above, and conical when viewed in profile. It is furnished with four muscular suckers, and the small depression at the apex of the head is surrounded with hooklets, varying from twenty-four to twenty-eight in number, which, when once seen, cannot be mistaken. The muscles of the tongue, neck, and shoulders are most liable to become infested, and next in order the intercostal muscles, and those of the lumbar region, loins, and thighs, while sometimes hydatids may be detected in large numbers in the muscular substance of the heart, and in the liver, lungs, and brain.

The disease more particularly affects young pigs, and those verging on maturity. The symptoms are very variable, and in mild cases the disease may not be suspected. If suspected, it is usual to examine the under surface of the tongue, when frequently the little bladders may be felt or seen. In the more advanced stage of the disease they may be detected under the tail, round the ears, or in the conjunctival membrane of the eye. When the disease becomes general and severe there is loss of appetite, the animal becomes stiff and awkward in its movements, and swellings are more particularly observed around the withers. Pork infested with these parasites is called *measly*, owing to the characteristic appearance of the flesh on section. When the flesh is dried or salted, the cysts shrink, and in order to detect them a small slice should be steeped in water. The flesh of measled pigs should not be used as food, even though the hydatids may apparently be few in number.

Measles in the ox, like pig-measles, is also parasitic, the entozoon, being the larval cestode of the *Tænia medio-canellata*, which is a human tape-worm infesting the small intestine. The symptoms of the disease, the development of the entozoon, and the appearance of the infested flesh and cysts, so closely resemble those already described respecting the *Cysticercus cellulosus* in the pig, that no further description is necessary. The meat should be condemned.

There is another parasite having for its habitat the lungs of sheep or oxen which may be mentioned here. It is known as the *filaria*, a thin worm from half an inch to three inches in length. It is not a common disease, and unless it induces severe inflammation of the lungs, fever, and emaciation, the meat may be passed.

Immature veal or lamb should be condemned as unfit for food if the animals have been born prematurely,

or have died during birth, when the flesh is known as "slink meat." It should also be remembered that the flesh of animals may become unwholesome owing to the animals having been accidentally or maliciously poisoned, and in these cases the meat may look perfectly healthy provided the animal has been slaughtered. In suspicious cases of this description the stomach and intestines should be carefully examined for traces of inflammation, and the first stomach, for pieces of meadow-saffron, bryony, or yew-leaves, etc. The flesh of animals slaughtered on account of accident may be passed, provided that the accident has not led to severe febrile disturbance, and the meat sets well; but if the animal has died from accident, the meat should be condemned, because the carcase has not been bled. The flesh is dark in colour, full of blood, sets badly, and rapidly decomposes.

It may further be laid down as a rule, that if an animal has been slaughtered while suffering from marked febrile symptoms, from whatever cause, or from inflammation of a severe type, pyæmia, erysipelas, or uræmia, the carcase should unhesitatingly be condemned as unfit for human food.

Section VI.—Examination of Food

1. *Butcher Meat.*—A healthy carcase should be well-bled, no part of it being dark or speckled, bruised or bile-stained. The meat should set well, so soon as the carcase cools, and should not present an emaciated appearance. It should not be flabby or pit on pressure, nor should it crackle, because this would indicate the presence of air.

When a carcase is inspected, the offal should be inspected too, and it should always arouse suspicion if the butcher says he has destroyed or thrown away the offal and cannot produce it. In oxen and sheep the offal

consists of the head, hide, feet, and all the internal organs with the exception of the kidneys; but in pigs the head, feet, and skin form part of the carcase. In examining the offal it should be noted that the skin is free from sores or pustules, that there are no signs of bruising, and that the hoofs are healthy-looking and firmly attached to the feet. The mouth and tongue should be free from patches or ulcers. The internal lining of the stomach should present no signs of inflammation, and should have no smell of physic, while the intestines should have a smooth uninflamed lining, and be free from ulcers or patches. The liver should not be friable, be of a rich brown colour, and free from abscesses or flukes. The spleen should be a gray colour outside, thin, long, and sharp (not rounded) at the edges, and on section should be dark inside. The lungs should be of a pink, bright colour, and spongy, and portions cut off should float in water. They should also be free from cavities, pus, or worms, and their surfaces should present no signs of inflammatory patches or recent pleuritic adhesions.

In order to acquire a practical knowledge of the healthy appearance of sound butcher-meat, whether in carcase or cut up for sale, the sanitary official should make repeated inspections of the contents of a butcher's shop whose trade is above suspicion, and he should also visit the slaughter-house and make careful examination of the various parts of the offal. His knowledge of unsound meat and diseased offal would be most readily gained by accompanying a meat-inspector on his rounds in one of our large towns.

The characters of good meat may be enumerated as follows:—

(1.) On section it should present a marbled appearance from intermixture of streaks of fat with muscle. This shows that the animal has been well fed.

(2.) The colour of the muscle should neither be too pale nor too dark. If pale and moist, it indicates that the animal was young or diseased; and if dark or livid, it shows that in all probability the animal was not slaughtered, but died with the blood in it. The muscles in pork, veal, and lamb are pale.

(3.) Both muscle and fat should be firm to the touch, not wet or sodden. The latter should be free from hæmorrhagic points, and the suet fat should be hard and white.

(4.) Any juice exuding from the meat should be small in quantity, be of a reddish tint, and give a distinctly acid reaction to test-paper. Good meat should dry on the surface after standing a day or two. The juice of bad meat is alkaline or neutral.

(5.) The muscular fasciculi should not be large and coarse, nor should there be any mucilaginous or purulent-looking fluid to be detected in the intermuscular cellular tissue.

(6.) The odour should be slight, and not by any means disagreeable. An unpleasant odour indicates commencing putrefactive change, or that the meat is diseased. By chopping a portion of the meat into small pieces, and afterwards drenching it with warm water, any unpleasantness of odour will be more readily detected. Another good plan is to thrust a long clean knife or skewer into the flesh, and smell it after withdrawal.

(7.) When meat is salted, the brine should not become sour or offensive.

When meat becomes bad through partial decomposition, owing to its having been kept too long, its chief characteristic is an offensive or putrid smell. The external surface is pale or livid, and, at a later stage, greenish. The meat is soft, tears easily, and loses its elasticity, and the juice is alkaline or neutral. The flesh

of animals which have not been slaughtered, or only slaughtered when in a dying state, is dark in colour and often purple, full of blood, sets badly, and readily decomposes. Diseased meat is usually sodden and flabby, often emaciated, with the fat discoloured or gelatinous-looking, and the smell unpleasant or sickly. The ribs should always be examined for pleuritic adhesions, and in cases of suspected dropping after calving the udders and peritoneal lining should be carefully scrutinised, while in all cases the flanks should be looked to, because it is generally in these parts that putrefactive change first sets in. When the offal can be obtained for inspection the various organs should be minutely examined, but it is seldom that the butcher who wishes to sell diseased meat leaves any of them exposed to the risk of detection, and this, as already said, should always arouse suspicion. If parasitic disease is suspected, the muscular fibre should be examined under the microscope. Cysticerci, though generally visible to the naked eye, can be accurately detected under a low power or by means of a good pocket-lens, and the hooklets should be always seen. In searching for trichinæ, it should be remembered, as previously stated, that the parts most likely to be infested are the diaphragm, the intercostal muscles, and the muscles of the flank.

Any departure from the natural colour of the flesh of a slaughtered animal should arouse suspicion. A magenta hue, a dark reddish brown or black hue, or a mahogany hue, are all of them indicative of diseased conditions, while a greenish hue is a sure sign of decomposition or gangrene. Iridescence, or "Peacock feather glint," according to Professor Walley, is seen on section under a variety of circumstances, as in blood diseases, prolonged febrile disorders, and difficult parturition. My attention, too, has been directed to a phosphorescent appearance presented by meat in the dark such as is often presented by fish.

Though this appearance is no doubt very rare, it would warrant, according to Professor Walley, the condemnation of the meat as indicative of grave histological changes.

When meat is seized, very often the defence is set up that it is intended for dog's meat; but if it is found in the butcher's shop, or dressed in the usual way, there is generally very little difficulty in obtaining a conviction. In cases of this description which are brought before the magistrates, and likely to be strongly contested, it is always advisable, if possible, to get extraneous evidence concerning the previous history of the animal, and the price at which it was sold, and in country districts this can often be ascertained.

There is no doubt that large quantities of diseased meat are used up in the making of sausages, and instances of serious illness arising from food of this description are not at all uncommon, especially where the sausages are not well cooked. Bad-smelling sausages, or sausages which have a nauseous or putrid taste, an acid reaction, or a soft consistence in the interior, are highly dangerous, and should always be condemned. Tinned meats too, and so-called potted meats, are liable to putrefactive change, and should therefore be carefully examined, particularly as regards smell and taste, before being used.

Before leaving this part of the subject, I may mention that it is the practice in the City of London to condemn the flesh of all animals infected with parasitic disease, such as measles, flukes, etc.; of animals that may have been suffering from acute, febrile, or wasting diseases; and of those which have died from natural causes or by accident; as well as all meat tainted by physic, or in a high state of putrefaction. It is also the practice to condemn the flesh of any animal which has been killed immediately before, during, or immediately after parturition, on the

presumable grounds that an animal would not be slaughtered under such circumstances unless, from some cause or other, death appeared to be impending.

2. *Horse-Flesh.*—Under the Horse-Flesh Regulation Act of 1889, horse-flesh shall not be sold as human food unless in a shop, stall, etc., conspicuously labelled. The flesh of the horse is darker than that of the ox, and the muscular fibre coarser. The fat is also of a yellowish colour, and softer. If the meat has not been boned there will be no difficulty in distinguishing it from ordinary butcher meat, because the bones and joints are much larger, and the ribs, which are more numerous than those of the ox, are more arched.

3. *Poultry.*—Good poultry should be fairly well fed, firm to the touch, and present a pink or yellowish colour, while the smell should be fresh, and not unpleasant. Stale poultry becomes bluish in colour, often green over the crop and abdomen, has a disagreeable odour, and the skin breaks readily.

It has been discovered during recent years that tuberculosis is a frequent disease not only of the poultry-yard, but of the pigeon-loft and pheasantry. In poultry the affection has been variously described as *croup* or *roup*, *diphtheria* and *diphtheritic aphtha*, but the discovery of the *bacilli* of tuberculosis has served to dissipate these theories. The disease commences in most instances in the mucous membrane of the mouth, the nostrils, or the eye, then extends to the mouth and throat, and later on to the bowels, mesentery, and liver. In the lungs the disease presents a croupous appearance, but in the walls of the crop and of the intestines, and in the liver, mesentery, and spleen, the lesions are nodular.

Fowl-cholera is another disease which may affect geese, ducks, turkeys, and pigeons, as well as domestic fowls. It is seldom, however, that any birds so affected

are exposed for sale. The symptoms of fowl-cholera when the disease does not become rapidly fatal are briefly these:—The feathers present a bristling appearance, the comb becomes limp and livid, the wings droop, the bird loses appetite and drinks much, and becomes swaying or dragging in its gait. Eventually diarrhœa sets in, muco-purulent at first, and later on streaked with blood. If the bird dies or is killed and prepared for the market, the flesh is found to be somewhat redder than usual, the substance of the liver more friable, and the interior of the intestines marked with extravasations. Decomposition sets in rapidly.

4. *Game.*—According to modern ideas game must be in a state of decomposition, or what is called more or less "high," before it is considered to be fit for the table. It is therefore very difficult to decide when such a stage of decomposition has been reached as would warrant its seizure. But when the flesh becomes putrid, and the odour offensive, there is no doubt that it is unwholesome and should be condemned.

As already pointed out, tuberculosis is a disease to which game, and, it may be added, rabbits are liable, and should any of the characteristic lesions be detected, there should be no hesitation in condemning.

5. *Fish.*—Fresh fish should be firm, and without any disagreeable odour. If the whole fish is held out horizontally there should be very little drooping of the tail. The fish usually hawked about the streets is generally more or less limp and soft, and if it is found to be offensive as well, there is no doubt that decomposition has set in, and that it is unwholesome. But fish which is apparently healthy often gives rise to serious symptoms, such as vomiting, diarrhœa, and prostration. Herrings, pilchards, and other kinds of fish may occasionally induce symptoms of poisoning, and it is not at all an

uncommon occurrence to find a prickly rash following the eating of healthy shell-fish.

6. *Fruit and Vegetables* may become unwholesome from decay or disease, and the principal indications are softening, discoloration, or mouldiness. Unripe food, such as windfall apples, are certainly unwholesome, unless well cooked. Good potatoes should be of fair size, give no indications of disease on section, be firm to the touch, and when cooked should not be close or watery. Potatoes which have been exposed to severe frost become soft and watery, and are rendered unfit for food.

Tinned fruits and vegetables, like tinned meats, are generally more or less contaminated with tin; but as the metal is not poisonous except in large dozes, the small amount which is generally found to be present is not injurious. Green peas, French beans, and other vegetables, such as pickles, are frequently adulterated with copper to retain the fresh green colour. This adulteration is no doubt injurious, and may readily be detected by leaving the clean blade of a knife in the liquor for a short time, when the copper will become deposited on the blade.

7. *Corn.*—This includes wheat, barley, oats, rye, rice, and maize. Smut, bunt, and ergot are the most common diseases affecting corn in this country, ergot especially affecting rye; bunt, wheat; and smut, barley and oats. They are all of them vegetable parasites, distinguishable under the microscope. Stored corn may become infested with an insect known as the weevil or by *acari*, and if stored when damp may become unwholesome owing to fermentive changes.

8. *Flour.*—What is called good household flour or "seconds" should contain very little bran, be quite white, or only slightly tinged with yellow, and should give no acidity or musty flavour to the taste. It should not be lumpy or gritty to the touch, nor should it yield any

odour of mouldiness to the sense of smell. When made into a paste with a little water, the dough should be coherent and stringy, and even in the dry state it should cohere when compressed.

The amount of gluten can be ascertained by washing carefully a known quantity of flour, made first into a rather stiff dough, until the water comes off quite clear. The gluten, when baked or dried, should be clean-looking, and should weigh at least 8 per cent of the quantity of flour taken for examination. A good flour will yield 10 to 12 per cent. Bad flour gives a dirty-looking gluten, which is deficient in cohesion, and cannot be drawn out into long threads.

Flour is sometimes adulterated with barley-meal, maize, rice, potato-starch, etc. Samples of doubtful quality should therefore be examined microscopically. *Fungi, vibriones,* and the *Acarus farinæ* are detected in flour which is undergoing putrefactive change.

Adulterations with mineral substances, such as chalk, gypsum, or carbonate of magnesia, are best detected by burning a weighed quantity of flour down to the ash which should not exceed 2 per cent.

What is called whole meal should always be well-ground, and should give no acid or mouldy taste.

Oatmeal is generally roughly ground, and contains a fair amount of envelope freed from the husk. If husks are present the probability is that the meal has been adulterated with barley. The starch should not be discoloured, and the meal itself should be agreeable to the palate. If the meal looks suspicious, it should be examined microscopically.

9. *Bread.*—The crust should be well baked, not burnt. The crumb should not be flaky or sodden, but regularly permeated with small cavities. The taste and smell should both be agreeable and free from acidity. Unless

there is a considerable quantity of bran in the flour, as in whole-meal bread, the colour should be white, not dark or dirty-looking. Bread is aerated with leaven or yeast by kneading the flour with water charged with carbonic acid, or by mixing it with baking powders. Unleavened bread, and many kinds of cakes and biscuits, are not aerated.

Bread may become heavy and sodden owing to bad flour, bad yeast, or a gummy mixture of ground-rice. It may become sour owing to the quality of the flour, or to excess of fermentation, or it may become mouldy owing to its having been kept too long, or stored in a damp place. Biscuits, and especially ship biscuits, are often attacked by weevils.

Good flour, well baked, yields about 136 lbs. of bread per 100 lbs. of flour, and adulteration is chiefly directed to increase this ratio by making the gluten hard, and the bread more retentive of water. Ordinarily a 4-lb. loaf loses about $1\frac{1}{2}$ oz. in twenty-four hours, and about 5 oz. in forty-eight hours. Wheaten bread is sometimes adulterated with barley-meal, oatmeal, or boiled rice, and in order to improve its appearance when it is made from inferior, damaged, or adulterated flour, a small quantity of alum is added, generally less than 50 grs. to the 4-lb. loaf. The readiest test for alum in bread is the test known as the log-wood test. A tincture of log-wood is made by digesting 5 grammes of log-wood chips in 100 cubic centimetres of strong alcohol, and a solution of ammonia is made by dissolving 15 grammes of carbonate of ammonia in 100 cubic centimetres of distilled water. A teaspoonful of the tincture of log-wood, and the same quantity of the ammonia solution, are mixed with a wine-glassful of water, and in this mixture a small crumb of the bread to be tested is allowed to remain for about five minutes. The bread is then removed, and dried at a gentle heat, when, if much alum is present, the bread

dries of a dark blue colour; if only a little, the colour is lavender; and if no alum be present, the bread dries of a dirty brown colour.

10. *Milk.*—Pure cows' milk, when placed in a tall narrow glass vessel, should be perfectly opaque, of a full white colour, free from deposit, and should yield from 6 to 12 per cent of cream by volume, the average being 8 per cent. When boiled it should not change in appearance, and when allowed to stand for some time there should be no deposit. As it is frequently adulterated with water, the specific gravity is an approximate test of the quality, and hence the use of the lactometer. The specific gravity varies from 1027 to 1036; if it falls below 1027 it shows that the milk is either very poor, or that a certain amount of water has been added. The following table by Dr. Letheby indicates approximately the amount of water adulteration according to the specific gravity and percentage of cream:—

	Specific Gravity.	Percentage volume of cream.	Specific Gravity when skimmed.
Genuine milk	1030	12·0	1032
Do. with 10 per cent water	1027	10·5	1029
Do. ,, 20 ,, ,,	1024	8·5	1026
Do. ,, 30 ,, ,,	1021	6·0	1023
Do. ,, 40 ,, ,,	1018	5·0	1019
Do. ,, 50 ,, ,,	1015	4·5	1016

According to Wynter Blyth, the following table gives the average percentage composition by weight of human milk and cows' milk:—

	Human Milk.	Cows' Milk.
Fat	2·90	3·50
Casein	2·40	3·98
Albumens, etc. . .	0·67	0·94
Milk Sugar . . .	5·87	4·00
Salts	0·16	0·70
Total Solids . . .	12·0	13·12
Water	88·0	86·88

After milk has been allowed to stand from four to eight hours, the cream rises, and the remainder of the milk becomes less opaque. The quantity of cream which separates varies from 6 to 12 per cent, or even more—a small percentage of cream being always retained by the milk, even although it is allowed to stand for twenty-four hours. The milk which is milked last at a single milking is called the "strippings," and is much richer in cream than the milk first milked, called the "fore-milk." Milk, too, varies very much in quality and quantity according to the breed of the cow, her age, health, number of pregnancies, the period which has elapsed since calving, and the nature of the food upon which she is fed. About twelve quarts is the daily average yield, but immediately after calving the yield may be double this quantity. The first milk obtained after calving is called *colostrum*, popularly known as "beestings." It is of a high specific gravity—about 1050, of a rich yellow colour, clots very readily, and has a taste somewhat like beaten eggs. Asses' milk and goats' milk, both of which are sometimes used for food, resemble cows' milk in composition, but the relative proportion of the constituents varies appreciably, the former having a lower specific gravity than cows' milk, and the latter a higher.

If cows' milk is used for the feeding of infants under nine months of age, it should be given diluted with water and the addition of milk sugar. Cows' milk contains much more casein and fat than human milk, and is therefore more difficult of digestion, because the curd of human milk produced by the action of the gastric juice is flocculent and easily assimilated, while cows' milk curdles in wet cheesy masses.

Milk is highly absorbent, and therefore becomes readily tainted with noxious or offensive vapours or smells, such as exhalations from middens or drains, or

the foul, close air of a dirty-kept dairy or pantry. It then presents the taste and smell of the absorbed impurity, rapidly decomposes, and is certainly unfit for human food. Very probably it is in this way that such fungi as the *Oidium lactis* are generated, and it is well known that milk so affected has frequently been the cause of gastric irritation and vomiting. Some maintain that the milk of cows which have eaten poisonous herbs, feed on sewaged grass, or drink polluted water, may be rendered unwholesome, but there is no reliable evidence in support of this view. Indeed, so far as feeding on sewaged grass is concerned, there is now an overwhelming amount of evidence to the contrary; and I know as a matter of fact that there are large quantities of milk sold daily in and around Leamington, obtained from cows fed exclusively on this grass during the summer, and that on every occasion on which samples have been analysed, it has been found to be richly flavoured and of excellent quality. It may also be noted that several analysts have made repeated experiments with the butter, and have found that it possesses none of those tendencies to putrefactive change which have been gratuitously ascribed to it.

But apart from becoming tainted when exposed to foul effluvia, milk often becomes unwholesome from keeping, especially in warm weather. It takes up oxygen from the air, and gives off carbonic acid gas; lactic acid is then formed from the lactin, and the milk curdles and becomes sour.

Milk from diseased animals, or from animals suspected of disease, should be examined microscopically. The normal constituents of milk, as seen under the microscope, consist of round oil globules, enveloped in a cyst, and scattered epithelial cells; but in milk obtained from diseased animals, blood, pus cells, and aggregated granules

may often be detected, and sometimes casts of the lacteal, tubes, while bacteria and small oval and round cells are not at all uncommon.

Disease in the cow often arrests, and almost always diminishes, the flow of milk. In anthrax and anthracoid diseases it is thick, of a bad colour, contains pus or blood cells, and rapidly decomposes. Milk from cows suffering from pleuro-pneumonia, garget or inflammation of udder, foot-and-mouth disease, tuberculosis, or, indeed, any acute febrile disorder, should be condemned as unfit for food. But the great danger always is that milk of this description is not unfrequently mixed with large quantities of good milk, and so may escape detection.

Then again, milk may become infected with the germs of animal disease; as from the mouth discharge of a neighbouring cow suffering from foot-and-mouth disease, or, as has occasionally happened, from the nasal discharge of a horse suffering from strangles, put up in the same outhouse. I have reason to believe, too, that symptoms of a diphtheritic nature have been induced by using milk obtained from a cow which the calf is allowed to suckle occasionally, when the calf itself was suffering from throat symptoms.

But the most severe outbreaks of disease arising from tainted milk, as will be shown in the following section, have been caused by admixture with polluted water, or from absorbing specific morbid germs. Many outbreaks of scarlatina have arisen through the dairyman or some members of his family having the disease, or sometimes owing to a delivery-can not having been thoroughly washed after having been brought from an infected house. Diphtheria, too, may be spread in the same way, and there is every reason to believe that if the milker is suffering from ulcerated throat of a diphtheritic nature, there is great danger of the milk becoming infected,

through the breath impinging on it as it flows into the can. The only safeguard against all these dangers is boiling the milk.

In most cases of falsification, milk is watered or creamed, or both watered and creamed. Watering is detected by a lowering of the specific gravity, and a diminished percentage of cream; but when creaming alone is resorted to, the specific gravity is raised and the percentage of cream diminished. When both are resorted to, the specific gravity may be normal, but the percentage of cream is, of course, always lessened. When milk has been falsified in this way, other substances, such as treacle, salt, turmeric, carbonate of soda, etc., have sometimes been added to improve the flavour and appearance; but, generally speaking, the use of a graduated vessel to determine the percentage of cream, and testing the specific gravity, will enable one to give a reliable opinion as to whether the milk has been tampered with or not. Suspicious samples should be sent to the public analyst for analysis.

In order to prevent fermentative changes when milk is conveyed long distances from country farms, it has recently become a somewhat common practice to add a little salicylic acid, boracic acid, or boroglyceride to the milk, and these adulterants constitute another possible source of danger.

11. *Butter.*—Butter should give no unpleasant or rancid taste. Adulteration with water or animal fats is best detected by melting the butter in a test-tube; the water, salt, or other substances remaining at the bottom. After separation of the casein by melting, good butter is entirely soluble in ether at 65° Fahr., while the fat of beef or mutton dissolves with great difficulty, and leaves a deposit. Adulteration with potato or other starch can be at once detected by iodine. Good butter, when

melted in a tall glass, should yield over 80 per cent of fat, the water and curds collecting at the bottom, leaving the pure fat as a clear-looking oil above. Adulteration with lard or other animal fats raises the melting point, while vegetable fats lower it.

12. *Margarine,* which is sometimes sold as butter in contravention of the Margarine Act, is composed chiefly of fats of animal origin, and is often treated with milk or genuine butter to make it resemble butter as closely as possible.

13. *Cheese.*—The quality of cheese is determined by the taste and consistence. Inferior cheeses are often soft and leathery, owing to the amount of water which they contain. Starch, which is sometimes added to increase the weight, may be detected by iodine. Cheese consists of casein coagulated by rennet, and it also contains a variable proportion of fat and salts. When it undergoes what is called the "ripening" process, oxygen is absorbed, ammonia and carbonic acid are given off, and the casein undergoes fatty metamorphosis. Cheese fermentation sometimes develops an irritant poison, known as *tyrotoxicon,* which causes dryness of the mouth, nausea, vomiting, diarrhœa, and extreme prostration. The same poisonous substance is sometimes developed by butter and cream.

14. *Eggs.*—An average-sized egg weighs about 2 oz. avoir. Fresh eggs, when looked through, are more transparent at the centre; stale ones, at the top. In a solution of 1 of salt to 10 of water, good eggs sink, while the stale ones float.

15. *Tea.*—The *bloom* or *glaze* of black and green tea is generally artificial. In the case of black tea, it sometimes consists of a coating of black-lead; and in that of green tea, it is usually a mixture of Prussian blue, turmeric, and China clay. Both kinds of adulteration are

detected by shaking the leaves in cold water, straining through muslin, and afterwards examining the deposit. Inferior mixtures, such as Maloe mixture, Moning congou, Pekoe siftings, etc., are largely imported into this country, and consist of exhausted tea-leaves, leaves of other plants, iron-filings, etc., with only a little good tea.

Good tea should yield a pleasant aroma, alike in the dry state and when infused in boiling water, and the flavour of the infusion should be agreeable. The test for tea of the first quality is to put a small quantity in a cup, pour water at the boiling point on it, taste it for its flavour, then allow it to stand until it cools, when it should throw up what is called a cream, The leaves, when spread out, should be small, serrated, elongated, and liver-coloured. If the tea is suspicious, the infused leaves should be spread out and carefully scrutinised, and any powdery deposit examined under the microscope.

16. *Coffee.*—The principal adulteration of coffee is chicory. The adulteration may be detected either by microscopic examination or by sprinkling a portion of the suspected sample on the surface of water, when the coffee will float and the chicory sink. The presence of chicory is also indicated, if, on opening a packet of coffee, the contents are found to be caked, or show any signs of caking.

Amongst other articles of food or drink which are liable to adulteration may be mentioned cocoa, mustard, pepper, confections, beer, wine, and spirits; but without entering further into this part of the subject, it will be sufficient to point out that any article of food or drink, or any drug which is supposed to be adulterated, should be submitted to a public analyst, on whose report proceedings may be taken under the provisions of the "Sale of Food and Drugs Acts, 1875 and 1879.

Section VII.—The Effects of Insufficient or Unwholesome Food on Public Health.

1. The minor effects of insufficient food are generally so intimately associated with those of other causes of disease, that it is impossible to estimate, with any approach to accuracy, their separate influence on public health.

Only those who have threaded the dingy streets and dirty courts of our large towns can form any adequate conception of the wide-spread suffering and disease which follow in the wake of actual want. Clothing and fuel even scantier than the food, overcrowding with all its attendant evils, sanitary arrangements of the worst description, rickety floors and reeking walls, all contribute to the heavy load of misery which the destitute have to bear. Indeed, as regards the civil population, the history of relapsing fever is almost exclusively a history of the ravages of disease arising from destitution, and the famines of the present century, especially those of 1817 and 1847, need only be referred to as evidence on this point. There is no doubt, too, that the large mortality among infants and young children is in great measure due to insufficient food, and at all ages there are crowds who from sheer want fall ready victims to some form of adynamic disease.

2. *Unwholesome Food.*—Although much of the apparent immunity from disease enjoyed by the large numbers who unwittingly indulge in unwholesome food at times is to be attributed to the antiseptic power of good cooking, there are also many instances on record in which food of the most putrid description is devoured without producing any ill effects. Thus, according to the late Sir Robert Christison, there are whole tribes of savages who eat with impunity rancid oil, putrid blubber,

and stinking offal; and in this country game is not considered to be in a fit state for the epicure's table until it is undergoing rapid putrefactive change. Admitting all this, however, there is abundant evidence to prove that serious consequences resulting from the use of unsound meat are of frequent occurrence, and in all probability a large proportion of cases of obscure disease owe their origin to the same cause. Moreover, it is but only logical to conclude, from general principles, that, as all diseases must affect the composition of animal flesh, and as active putrefactive change must at all events deteriorate its nutritive value, it is of the utmost importance to health that these substances should be obtained in as sound a condition as possible.

The following is a brief abstract of the more important facts connected with this part of the subject:—

(1). *Diseased Meat.*—Here, again, the evidence is of the same conflicting character. According to Dr. Letheby, enormous quantities of the flesh of animals that died of rinderpest in 1863, and more recently of pleuro-pneumonia, have been sent to the London market, sold, and eaten, without having produced any tangible ill effects. It is also well known that Scotch shepherds indulge largely in *braxy*, or diseased mutton, with apparent impunity; and, according to M. Decroix, the whole of the inhabitants of Paris would have suffered during the late siege if diseased meat were to any extent dangerous.

In the face of such evidence as this, it really becomes a question of public importance whether the flesh of *all* animals diseased should be condemned. As a matter of fact, about one-fifth of the meat at one time sold in the London market, according to Professor Gamgee, was of this description; and it has been urged that, if it were sold under its true character, and proper precautions were taken with regard to selection and cooking, the ill effects which

sometimes attend its use might not occur. It has been urged, too, that though such meat would be of inferior quality, it would be much cheaper, and thus come within the reach of many who are sorely in want of animal flesh, but cannot buy it at its present price. As it is, however, the butcher sells it under a fictitious character, and it is therefore the duty of the health officer to condemn it.

In the numerous cases of illness which have been attributed to the use of diseased meat, the symptoms are very similar to those occasioned by the use of putrid meat. The exceptional symptoms apply chiefly to the transmission of specific or parasitic disease. Thus, numerous instances have been recorded in which persons have been seized with malignant pustule after eating the meat of animals suffering from anthrax, and there is an increasing amount of evidence which goes to prove that tuberculosis may be transmitted to man through eating the flesh of animals suffering from this disease. As regards the development of parasitic disease, reference has already been made in the previous section to the fact that the *Cysticercus cellulosus* in measly pork produces the *Tænia solium*, and that of the ox or cow the *Tænia mediocanellata*. The *trichina* disease, again, which was so prevalent in Germany and elsewhere a few years ago, is due to the *Trichina spiralis* in the pig; while the *ecchinoccus* disease, so common in Iceland, owes its origin to the flesh of sheep and cattle which have become infested by the tænia of the dog. It appears that all these parasites are destroyed if the meat is thoroughly cooked before eating.

(2). *Putrid Meat.*—When putrefactive change sets in whether in butcher-meat, fish, fowl, or any other kinds of animal food, certain alkaline substances known as ptomanies are produced, which are often highly poisonous. These ferments are manufactured by the microbes of de-

composition, and may continue active after the microbes themselves have been destroyed. In Dr. Lauder Brunton's Croonian Lectures, delivered in 1889, he refers at length to some very interesting experiments conducted by himself and Dr. Alan Macfadyen of Edinburgh, which are of special interest to the sanitarian in the light thrown upon the relation of the ferments formed by microbes to poisoning by meat. His conclusions are as follows: "The practical application of these results in regard to the prevention of disease is that they seem to show that meat which has become tainted by the presence of putrefactive microbes may possibly be cooked sufficiently to destroy the microbes themselves, while the ferments they have formed continue to decompose the meat, and gave rise to poisonous substances. We can thus see how a cold beef-steak pie, or other meat, may become poisonous and produce serious symptoms, although the same food may have been eaten with impunity immediately after being cooled, for during the process of slowly cooling poisons may have been formed in the meat." He also points out that there are strong reasons for believing that the poisoning properties of these ferments are greatly intensified when they are produced by the combined action of ordinary putrefactive bacilli and the microbes present in the tissues of diseased animals.

It should also be borne in mind that in some cases poisonous properties are imparted to tinned meats by the action of their juices on the metal, and further that the envelopes of sausages, saveloys, etc., may in themselves be injurious. In the case of black puddings, again, there is the superadded danger of the possibility that the animal from which the blood has been obtained may have suffered from anthrax or some form of blood poisoning.

One of the most remarkable outbreaks which have been investigated in connection with food poisoning

occurred among persons attending the sale of the late Duke of Portland's effects at Wellbeck, Notts, in June 1880. Dr. Ballard, who was appointed to conduct the inquiry, found that as many as seventy-two persons were attacked with intense diarrhœa, with febrile symptoms, after partaking of luncheon, and four of the cases proved fatal. From among the various articles of food or drink which were partaken of at the luncheon, he was able to exclude everything except the ham and beef as being in any way implicated in the production of the disease, while other considerations suggested the hams or some of them as being most probably at fault. Microscopical examination of the provisions then showed that the hams were infested not with trichinæ, but with a special *bacillus* not previously known; while numerous specimens of this bacillus were found in the kidney of one of the fatal cases on *post-mortem* examination. Further, Dr. Klein, on feeding small animals on portions of the suspected ham, or inoculating them with it, developed in them similar symptoms to those from which the infected persons had suffered, and many of them died with acute inflammatory disease of one organ or another; while bacilli, taken from two of the hams and cultivated in the white of an egg, produced on inoculation similar results. Another outbreak of much the same character was investigated by Dr. Ballard in February 1881, and occurred at Nottingham. In this outbreak it was found that after eating baked pork, fifteen persons were attacked, and one died. In this instance no specimen of the meat could be obtained, but numerous bacilli were found in the body of the patient who had died. (*Report of the Medical Officer of the Local Government Board*, 1881.)

What is known as the Arlford Sausage Poisoning Case, also investigated by Dr. Ballard, occurred near Chester. In this case a gardener bought half a pound of sausage;

in three-quarters of an hour after eating it he was seized with choleraic symptoms, and after a week's illness he died. The sausage was part of a consignment of American manufacture, and portions were experimented on by Dr. Klein, some of which were found to be innocuous, and others very poisonous to small animals such as mice and rabbits. In all instances when the animals became ill the illness showed itself soon after feeding, and the *post-mortem* appearances gave evidence of the action of a soluble poison or ferment probably of bacterial origin. (*Supplement to Eleventh Annual Report of Local Government Board.*)

Another outbreak depending upon pork-pie poisoning occurred at Retford in 1887, and was investigated by Mr. Spear, one of the Local Government Board's Inspectors. In this instance 70 cases of illness, one of which proved fatal, were traced to the eating of pies and brawn made from the flesh of a pig which was believed to be healthy when slaughtered, and presumably so because no case of illness could be discovered from the consumption of the pork in its fresh state. The pies and brawn were cooked in a baker's oven, at a temperature of 220° Fahr. or above; and assuming that the meat was properly sterilised by cooking, the inquiry showed that it must have developed its noxious qualities in about forty-eight hours. Dr. Klein submitted one of the pies and some of the brawn to a bacteriological and microscopical examination. On opening the pie, there was observed a wide crack in which there was a layer of grayish-brown scum, in which were discovered dumb-bell shaped bacilli, some of which were mobile and others quiescent, and arranged in chains. There were also present micrococci in small groups, but these on cultivation did not prove to be pathogenic. The cultures of the minute bacilli, however, proved fatal to mice, but the remarkable fact was dis-

covered that cultures from ten days to a fortnight old were innocuous. Twelve mice fed directly from the pie became very ill, and one of the twelve died. (*Supplement to the Sixteenth Annual Report of Local Government Board.*)

In his Report to the Local Government Board for 1889, Dr. Buchanan refers to a sharp outbreak of diarrhœa at Carlisle, which circumstantial evidence had shown to be intimately associated with the consumption of pork and pork pies. Specimens of the pork and also of certain gravy-stock which had entered into the composition of the pies were forwarded to Dr. Klein for examination. He fed mice on these materials and induced disease of the intestines and lungs. In the lungs he found a particular kind of bacillus, which out of a variety of other bacterial forms was identified in the gravy-stock. These bacilli, whether from the stock or the mouse's lung, could be cultivated on suitable media, and the subcultures of the lung bacilli were found to have the same toxic property as the gravy-stock; "inoculation or feeding of other mice giving rise to the same intestinal and lung disease as in the previous mice, with bacilli capable of fresh cultivation characterising the newly induced lung disease." In commenting upon the experimental results of this outbreak Dr. Buchanan advances the hypothesis that the phenomena of "food poisoning" are claiming, on ever-growing evidence, to be regarded as true infective diseases.

(3.) Some kinds of fish, especially in warm weather and in hot climates, have been known to produce very severe symptoms. Thus, cases of acute urticaria, with swelling of the tongue, fauces, and eyelids, are frequently due to eating lobsters, crabs, or shell-fish; while gastro-intestinal irritation, sometimes of almost choleraic intensity, is by no means a rare consequence of eating putrid

fish of any kind, no doubt due to the poisonous alkaloids developed by the microbes of putrefaction. Professor Walley has observed that in dogs, more especially at sea-side resorts, septic forms of poisoning and choleraic conditions are more frequently produced by the devouring of putrid fish than by any other kind of animal matter. The disease known by the Spanish name of *siguatera* is of this description, and is common amongst the crews of vessels doing duty in the tropics when they partake of fish caught at the various stations as a change from the ordinary diet of the ship.

(4.) *Milk.*—In connection with the subject of unwholesome food, special notice should be taken of the spread of disease through the agency of milk. And first, it has to be noted that there is an overwhelming amount of evidence which proves beyond all doubt that the milk of cows, whose healthy condition is affected either by what they eat or by the water they drink, is deleterious and often productive of disease. The effect which food has on the milk-secretion is shown in ordinary feeding, when cows are in the beginning of the winter season first fed on turnips—the taste of the turnips being distinctly imparted to the milk. In the Western States of America the milk of cows affected with "the trembles" from eating the leaves of the *rhusoxicodendron,* or poison oak, has frequently been known to produce severe gastric symptoms among children, accompanied by great weakness and lowering of the temperature, and sometimes proving fatal. In France, where feeding-bottles are so largely used, a sudden and great increase of infantile diarrhœa and allied disorders was observed to follow the establishment of a large brewery in a certain district, and the cause was found to be the use of "brewers' grains," which are always injurious when they are kept till they are sour or ferment. Indeed, in America *swill milk,*

as it is called, or milk obtained from cows fed on distillery swill, is regarded as such an unwholesome food for children that its sale is prohibited by law. Then, again, all observers are agreed as to the deleterious effects of impure water on the milk of the cows drinking it; it keeps badly, and the butter is of low quality; nor is it hardly necessary to point out the risk of using milk from a cow under medicine, because, apart from the diseased condition of the cow, it is well known that all soluble salts may appear in the lacteal secretion.

Although it may be quite true that the milk of diseased cows has often been used without producing any appreciable ill effects, there is always a great element of danger, and on that account it cannot be too strongly insisted on that milk yielded by a cow suffering from any form of disease, and especially from a diseased condition of the udder or teats, should be condemned as unfit for human food. Whether the disease be constitutional or local—a mere rise of temperature or some casting of the hair or cuticle, a chaffed teat or some outbreak of pustules or vesicles—the only safe rule for the dairyman to follow is to exclude the milk of the affected cow from the common stock.

a. Diphtheria.—An inflammatory condition of the udder, known as *garget,* has been suspected of causing outbreaks of diphtheria in those using the milk, and Mr. Power, in a report presented to the Local Government Board in 1878 on an outbreak of diphtheria in North London, was led to the conclusion that this might have induced the disease. Although this assumption has not been clearly established by subsequent inquiries into other outbreaks of diphtheria which have been clearly traced to the agency of milk, Dr. Klein's researches concerning the behaviour of milk cows towards diphtheria, detailed at length in the report of the Medical Officer to

the Local Government Board for 1889, are of special interest because they throw a new light on those obscure outbreaks which have hitherto baffled inquiry as to exact causation. Briefly stated, the results of Dr. Klein's experimental researches are these: Two cows were inoculated behind the shoulder with broth subcultures of diphtheria bacilli derived from a human subject. One of these cows died on the fifteenth day, the other was killed on the twenty-fifth. Besides serious changes in the organs, which were found on *post-mortem* examination, the bacilli of inoculation were discovered to have multiplied abundantly at the spot of inoculation, and these, when transplanted into nutrient media, developed colonies of the same diphtheriæ bacillus. Both cows on the date of inoculation were, to all appearances, healthy and yielding plenty of milk, but about the fourth day small vesicles appeared on the udders of each cow, which rapidly passed into pustules and crusted ulcers, and afterwards similar vesicles running the same course were observed on the teats. In the lymph of the vesicles and pustules he states that "the bacillus diphtheriæ could be demonstrated unmistakably both in coreo-glass experiments and by culture." He next inoculated two calves with matter taken from the vesicles and pustules; similar vesicles and pustules showed at the spots of inoculation. The calves fell ill, were killed on the twenty-fifth day, and exhibited *post-mortem* appearances like those found in the cows.

But the most important experiment was made with the milk. On the fifth day milk was drawn from a healthy teat of one of the cows into a sterilised glass, with every precaution taken; a drop was spread on the surface of nutrient gelatine, and the colonies so formed, Dr. Klein asserts, "were unmistakably colonies of the bacillus diphtheriæ."

These experiments were carried out at the Brown

Institute, and a diphtheria outbreak among some cats kept in another shed is of peculiar interest, because it was traced to two cats which had been fed, contrary to orders, with milk from the inoculated cows.

The real significance of these experiments rests mainly on the fact that the eruption on the udders and teats of both cows passed with great rapidity through its several stages, and was, in fact, completed in about six to eight days. Now, in the well-known outbreak of diphtheria which occurred at York Town and Camberley in 1886, and which was most carefully investigated by Mr. Power, it was clearly proved that, though no human source of infection could be traced, the ability of the implicated milk to cause diphtheria was pronounced and persistent day by day from the 8th to the 18th of October. The whole of the evidence made it also clear that the milk had become infected before leaving the farm where it was produced, but the conclusion arrived at was to the effect that the method of infection of the milk was not demonstrable in the existing state of knowledge on the subject. During the course of the inquiry, however, there was this interesting fact elicited, that a veterinary surgeon, on examining the cows in the implicated dairy, found that though all the cows were healthy, two cows showed signs of chaps on their teats, and further, that at the beginning of November one cow, "which had suffered chapped teats, still had, at the site of a chap, a scab or crust, not unlike those which at a later stage of their malady had been observed to replace ulcers on the udders of certain Henden cows."

The Henden outbreak will be alluded to presently; but in the face of these experimental researches, the significance of the evidence of chapped teats having affected two at least of the cows in the York Town outbreak strongly emphasises the inference that diphtheria

was directly communicated from these cows through their infected milk.

Another outbreak of scarlatina, associated with diphtheria and sore throat, which occurred at Macclesfield and Upton in February 1889, may be placed in the same category. This outbreak was investigated by Dr. Parsons, and though in this instance the cows of the implicated dairy were certified to be healthy by competent veterinary authorities, it was made clear that the milk of a newly-calved cow, which had been recently purchased, was mixed three days after calving with the other milk sold on 23d January, the date of the outbreak; that this cow, while it showed no "chaps on teats," had a few bare patches on both rumps, around which the skin was scurfy and the hair could be easily pulled out. Another cow, which was purchased on the same date, namely, on 14th January, and which had calved three days previously, had also many bare patches on the neck and a few on the back and rump, while several of the other cows in the same shed had similar patches, but no sores or scabs on the udders or teats. The outbreak continued in operation from 23d January to 31st January, when the implicated milk-supply was stopped. But it is very significant that on the occurrence of fresh cases of illness in the same milk-run on 15th March the milk from the first cow mentioned, which calved on 20th January, was excluded from the general stock because it was found that in the early part of March some pimples or vesicles developed on one of the teats of this cow, and at the time her milk was rejected, scabs had formed on these. On Dr. Parson's second visit on 25th March he found a thin adherent scab about the size of a sixpence near the lower part of one teat. The teat felt sticky, and the milk flowed less readily from it than from the others, and had to be drawn off with a quill. The cow had lost flesh.

The peculiar features of this outbreak consisted in the mixture of scarlatinal, diphtheritic, and sore-throat cases; the frequency of vomiting and purging at the commencement; the sudden onset of the illness; the ill-defined character of the rash when it appeared; the scanty desquamation; the slight tendency to spread by infection; the absence of kidney symptoms; and the doubt entertained by the medical attendants that the cases which presented a rash were true scarlatinal cases, but rather cases of some form of blood-poisoning. (See *Report of Medical Officer of Local Government Board*, 1889.)

But apart from outbreaks with more or less well-defined diphtheritic symptoms, certain obscure throat affections have been traced to a tainted milk-supply, and notably an outbreak which occurred in Aberdeen in 1881. In this outbreak the sufferers were attacked by severe rigours, followed by febrile symptoms and extreme prostration. The tonsils were slightly enlarged, but there was no false membrane, while a marked feature was the swelling of the glands of the neck, and those above the clavicle. Over 300 persons sickened within a short time, and 90 families were attacked out of a total of 110 supplied by the same dairy. So soon as the milk-supply was stopped, the farther spread of the disease was at once arrested; indeed, its disappearance was as sudden as its onset. In this instance the water-supply was obtained from an uncovered cistern in the cow-shed, and on analysis it was found to be polluted; but though suspicion attached to the water, the abruptness of the outbreak points rather to some temporary tainting agency which was not discovered, although it was found to be connected with minute organisms in the milk. (*Sanitary Record*, 1881.)

Although the outbreaks of diphtheria attributed to milk supplies which have been recorded do not amount

to more than 20, it is interesting to note that in half of them no explanation whatever seems to have been suggested by the surrounding circumstances, while as regards other insanitary conditions at the dairy were found, in close relation with the milk, either in the form of untrapped drains, dirty milk-cans, dirty linen about the cans, dirty clothes for wiping the cans, or polluted water. Indeed, in reading the accounts of many of these outbreaks, we cannot help being impressed with the references to drains which are not properly disconnected, but which are either untrapped or open, and in such a position as to discharge their effluvia over the milk-vessels or the milk. These are just the conditions which are so frequently found to be associated with localised outbreaks of diphtheria or diphtheritic sore throat, and they suggest specific pollution of the milk in this way. It is quite probable, too, that milk may become specifically polluted by the breath of the milker should the milker be suffering at the time from diphtheritic throat, and further, there are strong presumptive grounds for believing that the milk of cows, which calves suffering from throat affections are occasionally allowed to suckle, may induce diphtheritic symptoms in those using the milk.

b. Foot-and-Mouth Disease.—The milk of cows suffering from foot-and-mouth disease, though no doubt frequently used with impunity, sometimes produces aphthous ulceration of the mouth and gums, with swelling of the tongue and great fœtor of the breath. Dr. Thorne reports an outbreak of this nature (see *Twelfth Report of the Medical Officer of the Privy Council*), and I have myself witnessed several well-marked cases of this description. Dr. Paine, Medical Officer of Health of Cardiff, found that concurrently with an epidemic of foot-and-mouth disease in the town, a severe form of sore throat became prevalent amongst children in the infected

neighbourhood, and microscopic examination of the milk led him to believe that this was the cause. (*Sanitary Record*, 1879.) Several other outbreaks have been recorded.

c. *Tuberculosis.*—It is notorious that stall-fed cows suffer in very large numbers from tuberculosis. Indeed, veterinary authorities have stated that at least 25 per cent of the cows kept in town dairies suffer from this malady, and this need cause no surprise when all the existing causes of the disease are found to be so general—cow-sheds overcrowded, dirty, and badly ventilated, and the cows themselves deprived of all healthy exercise and reduced to mere milking machines. It often happens, too, that the best-bred animals, which are usually the best milkers, suffer most from the disease. Nutrition is not much interfered with until the disease is far advanced, and even then the amount of milk yielded, though poor and watery, is so plentiful that the dairyman keeps the animal and mixes the milk with the general stock.

The dangers attaching to tubercular infection of milk are based on the following facts: The bacilli of bovine tuberculosis are identical with those found in the human organs, although the disease presents different anatomical characters in man and cattle.

According to the experiments, more especially of Martin, Galtier, and Bang of Copenhagen, milk which is found to contain tuberculosis-bacilli produces the disease either by ingestion when injected into the peritoneum of guinea-pigs, or by inoculation, and this also applies to cream, butter, and whey.

It is well known that pigs fed on dairy refuse are affected with tuberculosis of a most typical kind, and Dr. Woodhead of Edinburgh has recorded an outbreak among these animals which could be distinctly traced to the milk of three cows which were found to be suffering from marked tubercular mammitis.

In the *International Journal of the Medical Sciences* for November 1889, Dr. Ernst of Boston has summarised the conclusions which he has drawn from a most careful experimental investigation conducted under the auspices of the Massachusetts Agricultural Society in the following propositions: "1st and emphatically, That the milk from cows affected with tuberculosis in any part of the body may contain the virus of the disease. 2d, That the virus is present whether there is disease of the udder or not. 3d, That there is no ground for the assertion that there must be a lesion of the udder before the milk can contain the infection of tuberculosis. 4th, That, on the contrary, the bacilli of tuberculosis are present and active, in a very large proportion of cases, in the milk of cows affected with tuberculosis, but with no discoverable lesions of the udder."

To all this the objection has been raised that if all tuberculous cattle yielded tuberculous milk, the disease would be far more common amongst human beings than it really is; but the experiments of Koch and others on anthrax and cholera bacilli, when ingested, largely support the contention that it is only when the intestinal functions are interfered with, and when, in consequence, there are alterations in the structure and in the chemical constituents of the fluids of the alimentary canal, that tubercular bacilli can penetrate through the epithelial layer. There is, however, a strong confirmation of the view that tuberculosis is transmissable to man in the fact that the mortality of children under five years of age from tuberculosis of the peritoneum and mesenteric glands, and from primary ulceration of the intestines, is undoubtedly high. During the ten years 1871-1880 it amounted to 2·57 per 1000—a mortality approaching closely to that from measles.

d. Scarlatina.—Although the great majority of milk

scarlatinal outbreaks have been traced to human infection, the well-known outbreak at Hendon, Wimbledon, and the North of London in December 1885 served to show that cows are liable to a disease identical with, or very closely resembling, human scarlatina. This outbreak was investigated by Mr. Power, and the experimental researches which it opened up were conducted by Dr. Klein. There was no doubt at all that the outbreak was due to the milk supplied by the Hendon cows; that a certain number of the cows were found to be suffering at the time, or had been suffering, from vesicles or ulcers upon the teats and udders; that this eruption was infectious; and, further, that it had been first seen on a cow which had been purchased on 15th November. (See *Report of Medical Officer to Local Government Board* for 1885-86.)

The results and conclusions derivable from Mr. Power's inquiry and Dr. Klein's researches are best summarised in the words of Dr. Buchanan in his report to the Local Government Board for 1886-87:—

"(1.) The disease in man and in the cow alike is characterised by closely similar anatomical features.

"(2.) From the diseased tissues and organs of man and cow alike the same micrococcus can be separated, and artificial subcultures be made from it.

"(3.) These subcultures, no matter whether established from man or cow, have the property, when inoculated into calves, of producing in them every manifestation of the Hendon disease, except sores on the teats and udders; no doubt for the reason that the milk apparatus is not yet developed in calves.

"(4.) But—and this I learn from Dr. Klein's later observations while this report is in preparation—the subcultures made from human scarlatina and inoculated into recently calved cows, can produce *in those cows,* along with

other manifestations of the Hendon disease, *the characteristic ulcers on the teats*—ulcers identical in character with those observed at the Hendon farm.

"(5.) The subcultures, established either from the human or the cow disease, have an identical property of producing in various rodents a disease similar in its pathological manifestations to the Hendon disease of cows and to scarlatina in the human subject.

"(6.) Calves fed on subcultures established from human scarlatina obtain the Hendon disease.

"(7.) Children fed on milk from cows suffering under the Hendon disease obtain scarlatina.

"The above combine, I think, to form a mass of evidence to show that the Hendon disease is a form, occurring in the cow, of the very disease that we call *scarlatina* when it occurs in the human subject."

It is but right, however, to state that these views of the Medical Department of the Local Government Board have been contested by the Veterinary Department and by several eminent bacteriologists; the former holding that a possible human source of the disease at Hendon was not excluded, and that other cows which had the Hendon disease did not give rise to any scarlatina outbreak; whilst among the latter, Professor Crookshank maintains that a disease of cows in Wiltshire, presenting all the features of the Hendon disease, was in reality cow-pox, and that the *micrococcus scarlatinæ* described by Dr. Klein is merely the *streptococcus pyogenes* whose relation to scarlatina was definitely established by Fränkel and Freudenberg in 1885.

To add to the difficulties of arriving at any definite opinion of the evidence advanced in this controversy, it may further be noted that Drs. Jamieson and Edington, of Edinburgh, have also investigated scarlatina by biological methods, and that the latter ascribes the true cause of

scarlatina to a mobile bacillus. On the other hand, the extended experience of Dr. Russell, Medical Officer of Health of Glasgow, in respect to numerous outbreaks of milk-scarlatina, has fully convinced him that certain obscure diseased conditions in the cow may originate scarlet fever in man, while other observers hold that enteric fever is also a disease which is communicable to man through the milk secretion.

Although the greatest significance attaches to Dr. Klein's researches, more especially in respect to the obscure outbreaks of diphtheria and scarlatina to which reference has just been made, practical sanitarians argue that if these diseases are genuine bovine diseases, which as such are communicable to man, how comes it that the outbreaks recorded have been so comparatively few and in a measure so inconclusive? Then, too, there is the fact that bacteriologists do not agree as to the special characteristics of the so-called pathogenic microbe of either disease, or the inferences which should be drawn from the *post-mortem* appearances exhibited by animals which have been inoculated either with matter obtained from the assumed specific eruption or with subcultures developed from this material—some regarding these appearances as the manifestations of simple pyæmic or septic poisoning. Many competent authorities, therefore, still hold the opinion that until more facts are accumulated on which bacteriologists are agreed, it is desirable to reserve judgment.

But as to the important part which milk plays as an agency in the causation and spread of disease, irrespective of cow conditions, there is now a very copious literature which admits of general acceptance and agreement. Not only does milk undergo rapid fermentive changes when exposed to the air, which in themselves become injurious, but the great danger attaching to it as a carrier of

disease depends upon its remarkable powers of absorbing gases and vapours whether organic or inorganic. If, for example, milk is exposed to noxious vapours of any kind, it will very soon taste of them; and in like manner, if it be kept in any close or badly-drained place, where foul odours are perceptible, it will soon become tainted and unfit for use. Milk which has become acid from lactic fermentation is liable to cause sickness and diarrhœa in children, and if the *oidium albicans* is present in the milk it may give rise to thrush; while other fungi, such as *aspergillus*, penicellium, etc., cause gastric irritation. Moreover, there can be no doubt that much of the infantile diarrhœa which proves specially fatal during the summer and autumn months, is due to milk which either becomes tainted in this way, or by being put into feeding bottles which are seldom or never properly cleaned; and it is highly probable that this intestinal irritation is largely attributable to the formation of tyrotoxicon by decomposition of the milk in the intestine itself. Milk should never be stored in sculleries or larders, or in vessels made of lead or zinc; in the latter case it speedily absorbs salts of the metal and becomes poisonous.

The prime danger, however, attaching to milk depends upon the fact that not only in respect to its nutrient properties, but in respect to the temperature at which it leaves the body of the cow, it forms one of the best culture media for low forms of life, whether fungoid or bacterial. In large numbers of instances it has been proved beyond all doubt to act as the carrier of the infection of scarlatina, enteric fever, and diphtheria, and cholera has lately been added to the list. As regards scarlatina, the specific virus of the disease gains access to the milk in the form of epithelial scales from an infected person; enteric fever, by the use of specifically polluted

water for adulteration or washing the cans; and diphtheria by the breath or sputa. Amongst the milk outbreaks first recorded may be mentioned one of scarlatina in St. Andrews, by the late Professor Bell, in 1870; another during the same year in Penrith, by Dr. Taylor; and the well-known outbreak of enteric fever in Islington, also in the same year, by Dr. Ballard, now of the Local Government Board. Subsequent to that date numerous other outbreaks were reported, but one of the most notable amongst them was the outbreak of enteric fever in Marylebone, London, investigated by Mr. Power and the late Mr. Netten Radcliffe, in 1873, when it was proved beyond a doubt that the water used for dairy purposes on a particular farm, from which the milk was obtained, contained excremental matters from a patient suffering from enteric fever immediately before and at the time of the outbreak. (See Mr. Simon's *Reports*, New Series, No. II.)

In a paper read before the International Medical Congress in 1881, Mr. Ernest Hart gave a tabulated account of as many as 71 epidemics due to infected milk, 67 of which had been made the subject of detailed inquiry since the date of the Marylebone outbreak. Of these 50 were epidemics of enteric fever, 14 of scarlatina, and 7 of diphtheria; while the number of cases traceable to each of these diseases in the various outbreaks was estimated at 3500, 800, and 500 respectively. As regards enteric fever, the contamination of the milk was in 22 out of the 50 epidemics traced to the use of specifically polluted water for "washing the milk-cans," and no doubt in all of them water was the prime agent in producing the disease. In the majority of outbreaks of scarlatina, however, it was found that persons employed in the dairy were in attendance on patients suffering from the disease, or that the disease itself existed in the dairy.

Since that date Professor Davies of the Army Medical School, Netley, has collected particulars of 19 outbreaks of enteric fever and 18 of scarlatina, which are published in the Provincial Medical Journal for July 1889, and the list is constantly being added to. The more prominent of these milk epidemics from 1873 onwards formed the subjects of detailed investigation by the Medical Inspectors of the Local Government Board, and are recorded in the official reports.

As regards cholera, Dr. Simpson, Medical Officer of Health for Calcutta, recorded in his report for 1887 particulars of a slight outbreak which occurred on board a ship lying in harbour, resulting in nine cases and four deaths, in which the specific contagion seemed undoubtedly to have been conveyed by milk. In this instance it was clearly ascertained that, excluding all other possible causes, the native milkman who supplied the milk confessed to habitually diluting his milk with water from a tank into which dejecta from a cholera patient found access.

The special characteristics of milk epidemics are the usually sudden outbreak and its almost equally sudden cessation, when due allowance is made for late cases in infected households; the large proportion of attacks which are simultaneous or nearly so; and the very large proportion of households attacked which will be found to have a common milk supply, though the milk may not be distributed by the same retailer. It will also be found that if the households are classified according to the amount of milk supplied by the suspected dairy, the invasions will be proportionately more numerous in those using larger quantities; and hence the great incidence of the disease generally falls in households of the better class. This also applies to individuals, and therefore the attacks are more numerous among children and women than among men. In respect to outbreaks of enteric

fever this would be specially significant, because under ordinary conditions the disease chiefly affects adults ; while as regards scarlatina the type of disease, according to Mr. Power, is generally mild and the mortality low.

When an outbreak which is suspected to have a milk origin occurs in any locality, and the exact source of infection has not been traced, it is always advisable to recommend the inhabitants to boil the milk. So soon, however, as suspicion falls on any dairy, the employees, cows, premises, water supply, etc., should be carefully examined, and if the Health Officer has reason to believe that the milk supply is implicated it should forthwith be prohibited until the source of infection is removed or other sufficient precautions are taken (see Chapter xviii).

5. *Unwholesome Vegetable Food.*—As regards foods of this description it may be said that all articles which have become mouldy or partially decomposed are dangerous. Vegetables and fruits coming under this category should be condemned. On the Continent the ergot of rye has been productive of serious epidemics, and in this country alarming symptoms have frequently followed the use of flour which contains the ground seeds of *Lolium temulentum* or darnel. Flour which has a strong musty flavour should be condemned, and if dark in colour it should be examined microscopically.

CHAPTER III

AIR: ITS IMPURITIES, AND THEIR EFFECTS ON PUBLIC HEALTH

SECTION I.—COMPOSITION

THE average composition of pure atmospheric air per cent by volume is as follows:—

Oxygen	20·96
Nitrogen	79·00
Carbonic acid	·04
Ozone, mineral salts, and organic matters	traces.
Ammonia and watery vapour	variable.

With the exception of carbonic acid and aqueous vapour, the relative proportions of the other constituents remain tolerably constant throughout the globe. According to the late Dr. Angus Smith, the amount of oxygen varies from 20·99 per cent in the sea air of the west of Scotland to 20·91 in Manchester during frost and fog, while the carbonic acid ranges from ·03 to ·05 per cent. Indeed, in the closed courts and narrow streets of Manchester and London, where the atmosphere is stagnant, the air may contain only 20·80 per cent of oxygen, and even less, while the carbonic acid may exceed ·06 per cent. Both the carbonic acid and organic matters increase as we pass from rural districts to the suburbs of a town, and from the suburbs to more thickly-populated parts; but the former varies less than the latter.

The amount of aqueous vapour fluctuates greatly, and is mainly influenced by temperature. At a given temperature air cannot contain more than a certain quantity of moisture in suspension, and when it has taken up this quantity it is said to be saturated. In general, the air contains from 50 to 75 per cent of the amount requisite for complete saturation, the average amount being about 1·46 in 100 parts. If the quantity be not within these limits, the air is either unpleasantly dry or moist.

The ammonia, which exists as carbonate, chloride, sulphate, or sulphide, is present only in very minute quantities, and does not exceed one part in a million parts of air. Its variations are generally found to be parallel with those of carbonic acid.

In addition to these ingredients, ozone may perhaps be reckoned as a normal constituent, though it is generally absent in town air, and spectroscopic analysis has shown that the salts of sodium are everywhere present in greater or less abundance.

SECTION II.—IMPURITIES IN AIR, AND THEIR EFFECTS ON PUBLIC HEALTH.

Preliminary Remarks.—Impurities in air may be roughly divided into suspended and gaseous matters. While the presence of suspended matters is rendered familiar to every one in the shining particles which become visible in the direct rays of the sun, the well-known demonstrations by Professor Tyndall with the electric light have shown, perhaps more forcibly than heretofore, their almost universal diffusion. Particles of silica and silicates, of calcium carbonates and phosphates, of iron salts, and, in short, of every chemical constituent of the soil, are lifted by the winds and carried hither and thither. In inhabited places, carbon particles hairs,

fibres of cotton, wool, and other fabrics, starch-cells, etc., are found in great abundance. From the vegetable world are wafted seeds and the *débris* of vegetation, as well as spores, germs, pollen, and volatile substances. In like manner, the animal kingdom supplies germs of vibriones, bacteriæ, and monads, and particles of decayed or decaying tissues, such as epithelium and pus cells.

Microbes in air vary enormously according to locality and meteorological conditions. Dr. Miguel of Paris found that the average number per cubic metre of air was 455 in the Park of Montsouris, and 3910 in the Rue de Rivoli—these numbers representing the mean of six years' observations from month to month. He also found that the seasonal maximum occurred about midsummer, and the minimum about Christmas. Micrococci constituted 60 per cent of these bacteriform organisms, and the remainder consisted of bacilli and true bacteria.

The numerous gaseous matters which pass into the atmosphere, and render it impure, will be more conveniently noticed in the subsequent remarks concerning overcrowding, and the injurious effects of different trades and manufactures.

In towns the amount of organic matters and mineral dust will depend greatly on the ventilation of thoroughfares, and on the efficiency of the scavenging and watering of the streets. The wind raises minute particles from the surfaces, and often carries them far distances before they are deposited. In this way the air becomes the vehicle not only for mineral matters, but for infectious microbes and foul effluvia from dust-heaps, middens, and other filth accumulations. Indeed, were it not for the purifying agencies of the atmosphere, which are constantly at work, healthy existence would become impossible. Winds, however, and the ordinary movements of air sweep away impurities and bring pure air in their place;

injurious gases become diffused, diluted, or decomposed; animal emanations are absorbed in the processes of vegetation; suspended matters are washed down by the rains, or fall by their own weight; while many organic substances are oxidised, and thus rendered innocuous. Were it not for these purifying agencies, which are in constant activity, sanitary measures would prove futile; and, indeed, they are only successful in so far as they approximate to the preventive and remedial means which Nature employs.

1. *Air vitiated by Respiration.*—A healthy average-sized adult at rest breathes at the rate of 17 respirations per minute, and at each respiration about 30·5 cubic inches of air pass in and out of his lungs. The composition of this respired air is roughly as follows:—Oxygen, 16·96 per cent; nitrogen, 79·06 per cent; and carbonic acid, 4·04 per cent, together with watery vapour and certain undefined organic substances. In other words, the air in the lungs loses on the average 4 per cent of oxygen and gains 4 per cent of carbonic acid, while the nitrogen remains unchanged.

The amount of carbonic acid which is given off by an adult, as calculated from the above figures, will therefore be about 0·72 cubic feet per hour. According to Pettenkofer, this amount is increased by exertion in the following proportion:—In repose, 2; during gentle exercise, 3; and at hard work, 6. In both sexes the amount increases up to about the thirtieth year, but beyond the eighth year the exhalation is greater in males than in females. When applied to a mixed community of adults of both sexes the average amount exhaled by an adult during the twenty-four hours has been estimated by Dr. Parkes as 16 cubic feet, or about 0·6 cubic feet per hour, and this is the figure which is usually taken as the basis of all calculations on ventilation and air supply.

The quantity of watery vapour thrown off by the skin and lungs varies according to the individual and the hygrometric condition of the atmosphere. It has been estimated at from 25 to 40 oz. in the twenty-four hours, and requires, on the average, 210 cubic feet of air per hour to retain it in a state of vapour.

The organic matter given off has never been accurately determined. It has a very fœtid smell, and is but slowly oxidised. It is believed to be molecular, and may be said to hang about a room like clouds of tobacco-smoke, and, like tobacco-smoke, the odour is difficult to be got rid off, even after free ventilation has been resorted to. It darkens sulphuric acid, and decolorises solutions of potassium permanganate. When drawn through pure water it renders it very offensive. It is certainly nitrogenous, and probably in combination with water, because hygroscopic substances absorb it most readily. It promotes the growth of micro-organisms, and milk, meat, or other food exposed to it rapidly becomes tainted. In sick-rooms it is associated with pus-cells, micro-organisms, and other emanations of disease. As much as 46 per cent of organic matter has been found in plaster taken from the walls of a hospital ward in Paris, and Miguel has estimated the number of microbes in the Hotel de Dieu at 79,000 per cubic metre of air.

As the ammonia, and more especially the albuminoid, may be taken as an index of the amount of organic impurities contained in air collected at various places, the following summary of analyses, by Dr. Angus Smith, is instructive:—

Air obtained from	No. of Experiments.	Free Ammonia. Grains per Million cubic feet.	Albuminoid Ammonia. Grains per Million cubic feet.	Total Ammonia. Grains per Million cubic feet.
Innellan (on the banks of the Clyde) . . .	1	22·845	60·228	83·073
London	18	26·780	65·947	92·727
Glasgow	4	34·169	133·264	167·433
A bedroom . .	3	44·305	104·118	148·423
A midden . . .	3	146·911	181·524	328·435

According to a report on the air of Glasgow by Dr. Russell and Mr. Dunnachie, published in May 1879, nitrogen, as free and albuminoid ammonia, was found to be always in excess in the two centric stations of observation in the city, when compared with analyses made of the air collected at an eccentric station; but it was also found that the amount of potential or albuminoid ammonia became much lower in the month of July, clearly showing, especially when the amount of sulphur is taken into account, that both forms of ammonia are "largely derivatives of the rapid combustion of fire applied to wood or coal." These experiments have been confirmed to a certain extent by those which have been carried on for some time back at the observatory of Montsouris, in the neighbourhood of Paris, and serve to prove that the amount of ammonia cannot be relied on as an index of the insalubrity of air without taking into account the natural history of each sample.

Practically speaking, the amount of organic matter in air vitiated by respiration is found to increase as the carbonic acid increases. According to Dr. Parkes it becomes distinctly perceptible to the sense of smell when the carbonic acid in an inhabited room amounts to ·7 per 1000 cubic feet of air—a statement which has been frequently verified by other experimenters. This amount,

however, is often found to be enormously increased; thus, in seventeen samples of air from public schools in America Dr. Endemann found the carbonic acid varying in amount from ·9 to 3·5 per 1000 cubic feet of space.

Briefly, then, the changes produced in an occupied air-space by respiration and transpiration are the following:—The amount of oxygen is greatly lessened, the carbonic acid and watery vapour are largely increased, ammonia and organic matter are evolved, and suspended matter in the shape of low forms of cell-life and epithelium scales is thrown off.

The effects of breathing considerable quantities of carbonic acid in air otherwise pure have not yet been determined with sufficient accuracy. Dr. Angus Smith has found that 30 volumes per 1000 cubic feet of air produced great feebleness of the circulation, slowness of the heart's action, and quickened respiration; but he experienced no discomfort in a soda-water manufactory, where the amount was 2 per 1000 volumes. On the other hand, Pettenkofer and Voit found that no discomfort was experienced from long exposure when as much as 10 per 1000 volumes was present. In respired air, however, headache and vertigo are undoubtedly produced in many persons when the carbonic acid exceeds 1·5 per 1000 volumes; but probably this is as much due to the presence of organic effluvia, and the diminution in the quantity of oxygen, as to the increase in the amount of carbonic acid. Yet it must be borne in mind that even a small excess of carbonic acid interferes with healthy physiological action, inasmuch as it prevents the sufficient exhalation of the gas itself, and induces an undue accumulation of it in the blood. In like manner, the quantity of oxygen absorbed is lessened, and there is consequently a retardation of those oxidising processes which are requisite for the complete elimination of effete matters

from the system. But while there is always an increase in the amount of carbonic acid, there is likewise, as already pointed out, a marked diminution in the quantity of oxygen in respired air. Thus Dr. Angus Smith found that the percentage of oxygen in the open air of a suburb of Manchester amounted to 20·96; in a sitting-room, to 20·89; in the pit of a theatre, to 20·74; in the Court of Queen's Bench, to 20·65; and in the sumpt of a mine, to 20·140. It does not follow that, because pain or discomfort is not always experienced in a vitiated atmosphere, no harm has been done. The effects may be slowly and imperceptibly cumulative, but they are none the less injurious, and they are now recognised as being amongst the most potent and wide-spread of all the "predisposing causes" of disease.

Speedily fatal results, arising from overcrowding and the want of fresh air, are familiar to every student of medicine. Out of the 146 prisoners confined in the "Black-Hole of Calcutta," 123 died in one night; and it is significant that many of the survivors afterwards succumbed to "putrid fever." Nor have similar instances been wanting in this country. Of the 150 passengers that were shut up in the cabin of the Irish steamer *Londonderry*, with hatches battened down during a stormy night in 1848, 70 died before morning. No doubt, in these two catastrophes, the direct cause of death was asphyxia; but the fact that "putrid fever" attacked many of those who were carried out alive from the Black-Hole of Calcutta showed that the fœtid exhalations to which they were exposed must have aided largely in destroying the lives of the immediate victims. Indeed, it is admitted by all physiologists that the re-breathing of fœtid matter thrown off by the skin and lungs produces a kind of putrescence in the blood, in proportion to the amount inhaled and to the period of exposure to its influences.

Of this species of poisoning the history of the "Black Assizes," in the sixteenth, seventeenth, and eighteenth centuries, furnishes many terrible examples. Jail, or typhus, fever, according to Dr. Murchison, was frequently generated *de novo* solely in consequence of the disastrous effects of overcrowding and deficient ventilation, and the disease thus generated often spread from the court-house, where the prisoners were tried, to the surrounding population. Even so late as 1815, Harty showed that typhus was being constantly generated in the prisons of Dublin, whenever they became overcrowded with convicts prior to the periodical transportation of the accumulated numbers to a penal settlement. Or, to come to more recent times, one finds Dr. Buchanan reporting to the medical officer of the Privy Council regarding an extensive epidemic in Merthyr Tydvil in the beginning of 1870, that it was true typhus fever, and that he referred it to overcrowding, and to want of ventilation in the houses of the poorer people.

Such are some of the more direct and palpable effects of overcrowding and deficient ventilation; but there are others, perhaps equally grave, though not so well pronounced, which cannot be overlooked. All the so-called zymotic diseases, for example, are more specially fatal, and spread with the greatest virulence, in densely populated and badly ventilated districts; and it is in these "fever-nests" that epidemic diseases are attended with the highest mortality and the greatest sick-rate.

Of other diseases developed by respired air there can be no question that phthisis pulmonalis holds a prominent place on the list. A large mass of evidence has been collected from various sources bearing on this point, but the fact is now so fully recognised by the medical profession generally that a few instances will suffice. In the celebrated Report of the Army Sanitary Commission,

published in 1858, it was proved beyond all doubt that the excessive mortality from consumption amongst soldiers, and in particular regiments, was due to overcrowding and insufficient ventilation. Previous to that inquiry the cubic space per soldier in the barracks of the Foot Guards only amounted to 331 cubic feet, and the phthisis mortality was as high as 13·8 per 1000. In the Horse Guards, on the other hand, with a space per man of 572 cubic feet, the mortality from phthisis did not exceed 7·3 per 1000. It was found that phthisis prevailed at all stations, and in the most varied and healthy climates, the vitiated air in the barracks being the only condition common to all of them. In consequence of this excessive mortality, the Commissioners recommended that the cubic space allowed per man in barracks should be increased and the ventilation improved, with the result that, from the time their recommendations were acted upon, the number of phthisical cases occurring at all these stations has materially diminished. Similar evidence is afforded by the statistics of the Royal Navy, and notably as regards the civil population, in the Report of the Health of Towns Commission, published in 1844. Koch's discovery of the tubercle bacillus which is present in the breath and sputa of phthisical patients affords strong support to the views previously entertained by many that in crowded rooms the disease is infectious. As Dr. Ransome of Manchester has pointed out, it is highly probable that the sporulation of the bacillus is greatly assisted by contrast with the kind of organic matter found in such atmospheres ; but whatever the explanation may be, there can be no doubt that phthisis is intimately associated with over-crowding, deficient ventilation, or the moist effluvia in ground air arising from damp and dirty soils, and that when these conditions are absent its capability of propagation is very limited. But in addition

to phthisis, other lung affections, such as pneumonia and bronchitis, are generated to a large extent under like conditions, and the same may be said of scrofula, rickets, and other diseases of an adynamic type. In their report to the Local Government Board on back to back houses, Dr. Barry and Mr. Gordon Smith showed that there was little doubt that the want of thorough ventilation *per se* gives rise to an increased mortality from phthisis, lung diseases, and diarrhœa.

When air is vitiated by the exhalations of the sick, as in hospitals, there is a risk of gangrene and erysipelas spreading, especially in the surgical wards. The period of convalescence in many cases is retarded, and the mortality rate increased. Pus-cells and putrefying particles are thrown off from purulent discharges, and, finding a suitable nidus elsewhere, may communicate a special disease, and thus act as a true contagium. The prevalence of purulent ophthalmia, under certain conditions, and the spread of lung-disease in badly-ventilated ships, when the disease appeared to be propagated from person to person, can only be fully explained on some such theory as this.

2. *Air rendered impure by combustion.*—Bituminous coal when burnt in an open fireplace gives off three times its weight of carbonic acid gas, one per cent of its weight in fine carbon and tarry particles, and small quantities of carbonic-oxide, sulphurous and sulphuric acid, bisulphide of carbon, and steam. All these products of combustion are discharged into the outer air, and, with the exception of the sooty and tarry particles, are rapidly diffused and diluted. The sulphurous acid in the air of smoky towns renders the rain acid, and proves very destructive to vegetation; and in conjunction with the sooty and tarry particles, proves very injurious and irritating to people suffering from bronchitis and asthma. During dense fogs,

these injurious effects are increased, and the mortality from lung diseases always rises.

The products of combustion of coal-gas, on the other hand, escape into the air of the room where the gas is burnt. One cubic foot of coal-gas produces, when burnt, two cubic feet of carbonic acid, together with traces of sulphurous acid. Hence if the cubic space or ventilation is deficient, the contained air becomes more speedily devitalised by the deprivation of its oxygen, while the impurities of respiration are supplemented by those of combustion. In workshops, living-rooms, or churches where cast-iron stoves are used, carbonic oxide may be given off, and this gas is so very poisonous that one per cent in the air may cause asphyxia. Cases of carbonic oxide poisoning have also been reported when coke is burnt in open grates. It is further worthy of note that Professor Corfield has directed attention to cases of ulcerated sore throat which he attributed to slight escapes of coal-gas from leaking pipes or burners.

But in addition to the impurities of respiration and combustion, the air of inhabited rooms is often still further vitiated by household dust or effluvia, depending in great measure upon neglect of cleanliness. In towns this strictly domestic dust is largely increased by the minute particles which find an entrance through doors and windows; and though this cannot be avoided, much may be done to get rid of it, and prevent its undue accumulation, by thorough and systematic house cleansing.

Then, too, it is well known that cases of arsenical poisoning may arise from the diffusion of particles of arsenic or arseniuretted hydrogen from newly painted surfaces, or from wall-papers which contain arsenic. As a rule the symptoms are not severe, and do not go beyond conjunctivitis, irritation of the throat, nausea, and diarrhœa; but the induced debility may continue a long

time before the cause is suspected. In papering a room it is important to make sure that all the old paper is peeled off, and the plaster well washed, and it is also important that the paste or size used should be perfectly fresh.

3. *Air rendered impure by Sewage and Cesspool Effluvia, and other animal matter.*—Amongst the gases generated by the decomposition of fæcal matter, whether occurring in sewers or cesspools, may be enumerated carbonic acid, nitrogen, sulphuretted hydrogen, light carburetted hydrogen, and ammonium sulphide. Dr. Letheby found that sewage-water, excluded from air, and containing 128 grs. of organic matter per gallon, yielded 1·2 cubic inches of gas per hour during a period of nine weeks. But the amount of gaseous products given off under ordinary circumstances must vary greatly, according to the dilution of the sewage, the rapidity of flow, temperature, ventilation of the sewers, etc. In comparing the results of analysis made by various chemists, it would appear that the oxygen is diminished, and the carbonic acid greatly increased, but that sulphuretted hydrogen and ammonium sulphide, when present, exist only in very small quantities. The peculiarly fœtid smell of sewage gas is therefore owing to the presence of organic matter, whose exact chemical composition, however, has not been determined. Dr. Odling believes it to be carbo-ammoniacal. It is alkaline in reaction, and speedily decolorises solutions of potassium permanganate. Like other organic effluvia, it promotes the growth of fungi, infects milk, and taints meat.

Of late years a considerable amount of attention has been given to the micro-organisms which exist in sewer air by Miguel and Hesse abroad, and Carnelly and Haldane in this country. Contrary to what might have been expected, sewer air under ordinary conditions is found to be remarkably free from micro-organisms which are cap-

able of cultivation on nutrient media at ordinary temperatures, and the explanation appears to be that as the internal surfaces of pipe-drains and sewers are always more or less damp, the microbes cling to these moist surfaces and are thus prevented from floating in the air. In old and defective sewers, however, and even in fairly good ones when the weather is warm and dry, putrefactive bacteria undergo enormous multiplication, fermentative changes are induced, and gases are formed which bubble up and break on the surface. In large towns and in narrow streets, where there are sewer ventilators, the odours of sewer air are at times very offensive and overpowering; while the foul effluvia given off by cesspools, liquid privy cesspits, soak-pits, and the like, are often even more abominable.

It is doubtful whether the effects of sewer-air upon the health of men employed at work in sewers can be said to be very injurious. But it should be remembered that these labourers are picked men, and that many are obliged to give up the work after a short trial. At one time it was maintained that cases of enteric fever cropped up amongst them, and possibly in the days of old sewers, which were seldom flushed and never properly ventilated, this allegation may have been true; but in the present day such cases are rare, if they occur at all. It appears, however, that the men occasionally suffer from ophthalmia, and that the occupation tends greatly to aggravate general disease. But whatever injurious effects may accrue, it seems to be quite certain that constant exposure to sewer-gases diminishes the risk of being injured by them. A remarkable instance of this apparent immunity enjoyed by workmen, and the disastrous effects upon those whose exposure to such gases was only casual, is afforded by an event that occurred at Clapham in the autumn of 1829:—20 out of 22 boys at the same school

were seized with violent vomiting, purging, prostration, and fever within three hours. One boy had been seized with similar symptoms two days before, and died; another also succumbed. So alarming was the outbreak that poisoning was suspected; but after careful investigation, it was found that the sole cause of disease was to be attributed to the opening of a drain at the back of the house. This drain had been choked up for many years, and had been opened two days before the first illness occurred. The effluvia from the drain were most offensive, and the boys had watched the workmen cleaning it out; none of the workmen, however, were subsequently attacked with any of the symptoms which so seriously affected the boys.—(*Murchison.*)

While numerous other instances are recorded of the evil effects of the air of sewers, cesspits, drains, etc., in producing temporary ailments, such as nausea, vomiting, diarrhœa, and headache, the great interest which attaches to this important subject rests on the development and spread of enteric fever. Without entering at present into the discussion as to whether this fever is purely specific, or may be generated *de novo*, there can be no question that the polluted air from cesspits, drains, and sewers becomes the medium through which the disease is frequently propagated, if not engendered. The sewer-air, laden with *morbific ferments* or *microbes*, readily finds its way into houses, more especially in cold weather, on account of its greater tension, and in consequence of badly trapped or imperfectly ventilated drains. It may be inappreciable to the senses, but its baneful effects make themselves felt none the less, and frequently exhibit themselves in houses which in other respects are replete with every comfort which wealth can command. Indeed, it would appear that persons of the upper and middle ranks in towns are more liable to be attacked by enteric

fever than the poorer classes, and for this reason—the houses of the former are more generally connected with sewers, and, either from structure or situation, are of higher elevation, so that the light sewer gases, in obedience to natural laws, are more apt to accumulate in the drains of such houses, and, when the drains are not properly disconnected and efficiently trapped or ventilated, to effect an entrance into the houses themselves. Thus it happens that a system of sanitary engineering, which is intended to prevent, and does prevent, the development of disease, not unfrequently furnishes the readiest means for its propagation. For example, the outbreak of enteric fever in York which prevailed in the autumn of 1884, and was investigated by Dr. Airey of the Local Government Board, was attributed by him "to the exhalations from the ill-ventilated sewers, under the influence of a very dry and warm season."—(*Special Report to the Local Government Board*, 1885.) All outbreaks of this description, however, could be frustrated if sewers and drains were properly constructed and kept properly flushed and ventilated.

Two other points connected with the propagation of enteric fever deserve notice:—(1) it seems to be clearly established that the disease may be contracted by inhaling the effluvia from enteric stools previous to their being disposed of; and (2), that if these stools be thrown into a common privy, the disease is almost certain to be conveyed to others who frequent the privy; hence the necessity of disinfecting all discharges from the patient so soon as they are passed.

Amongst other serious consequences of fæcal emanations, the occasional spread of cholera and the occurrence of autumnal diarrhœa are specially to be noted. The outbreak of cholera in the City of London Workhouse, in July 1866, was shown by Mr. Radcliffe (*Ninth Report of*

Medical Officer of the Privy Council) to have taken place, in all probability, in consequence of a sudden efflux of sewer-air from a drain containing choleraic evacuations. Autumnal diarrhœa, again, is found to prevail when the season is warm and dry, and more particularly in badly-sewered districts. In Leicester, which for many years back has been notorious for its excessive mortality rate from summer diarrhœa, Dr. Tomkins, the Medical Officer of Health, has observed that soon after the temperature of the ground at a depth of one foot has reached 59° to 62° Fahr., the causes producing the disease begin to operate, and are confined to the low-lying parts of the borough, where the sewers are foul and retain much deposit, and the sewage percolates into the surrounding soil. This polluted condition of the soil at this temperature appears to be highly favourable to the development of bacteria, and as the temperature falls the disease begins to disappear. Dr. Tomkins has also ascertained experimentally that in those districts of the borough where summer diarrhœa is most prevalent, the air teems most abundantly with microbes or their spores; and that these spores, when cultivated, possess the property of inducing diarrhœa in the human subject. But apart from this form of specific diarrhœa, outbreaks of diarrhœa and dysentery, associated with cases presenting all the symptoms of true enteric fever, often crop up in isolated institutions, such as County Lunatic Asylums, where the drainage is found to be very defective, and abundant outlets for sewer-gas have been established by rat-holes. Quite recently I have had the opportunity of inquiring into an outbreak of this description, and there can be no doubt that isolated cases of a similar character are still plentiful enough in houses which are found to be badly drained or sanitary appliances defective. In rural districts, summer diarrhœa is largely associated with foul privy cess-pits or deep-

midden ash-pits, and there are good grounds for believing that many sporadic cases of enteric fever are traceable to the foul effluvia given off by the putrefactive changes which are set up, and which appear to become increasingly virulent, and contract more infective properties as scavenging is neglected, especially during warm weather.

Cases of diphtheria, ulcerated throat, membranous croup, puerperal fever, pyæmia, septicæmia, hospital gangrene, and other ill-defined ailments, have all been found to be associated with drainage defects; but why sewer gas or cesspool effluvia should be the apparent cause of so many dissimilar diseases has not been fully explained; very probably the micro-organisms are pyæmic and not specifically pathogenic, and the disease manifestations are induced according to the part of the mucous membrane attacked, or the wound or abrasion which may become infected.

According to the evidence of Sir Henry de la Beche and Sir Lyon Playfair, in the Second Report of the Health of Towns Commission, there are strong presumptive grounds for believing that emanations from streams polluted by fæcal matter may be injurious to the health of inhabitants living on their banks. It is stated that many of them were pale, and suffered from dyspepsia, and that cases of fever, when they occurred, were increased in severity. In other instances, however, no such effects have been traced.

As regards the effects of effluvia from decomposing animal matter, such as the effluvia from decomposing carcases, the air of graveyards, the effluvia from manure-heaps, etc., on almost all these points the evidence is very conflicting. The preponderance of opinion, however, leaves no room for doubt that the effects of all such effluvia upon the health of the general population, when exposed to their

influence, are more or less injurious; and in support of this view the following amongst many other confirmatory instances may be quoted:—

(1.) The effluvia arising from the putrid remains of horses killed on the field of battle have frequently given rise to outbreaks of diarrhœa and dysentery amongst the soldiers. In the French camp, before Sebastopol, when numbers of the bodies of horses lay putrefying and unburied, the effects were so serious that the spread of typhus was supposed to be due to this cause.—(*Parkes.*)

(2.) According to the evidence summed up in the Report on Extramural Sepulture in 1850, the vapours given off from thickly crowded graveyards, if not actually productive of disease, do certainly increase the sick- and death-rate of the immediate neighbourhood. Houses built on parts of disused burial sites, or in close proximity to them, would be rendered unhealthy by the entrance of impure ground-air.

(3). Frequent limited outbreaks of disease have been traced to the pan-manure mixed with ashes which is conveyed in canal boats from large towns and deposited in heaps at wharves or other landing-places in neighbouring rural districts. Such heaps, if allowed to remain in close proximity to houses, are not only extremely offensive, but may give rise to diarrhœa, ill-defined typhoid symptoms, or ulcerated sore-throat of a diphtheritic character, and the risks are intensified if children are allowed to play on or near the heaps.

4. *The Air of Marshes.*—This generally contains an excess of carbonic acid, light carburetted hydrogen, watery vapour, sulphuretted hydrogen, and organic effluvia. It also abounds with the *débris* of vegetable matter, infusoriæ, and, according to some bacteriologists, bacilli malariæ.

The more serious and characteristic effects of marsh miasmata are intermittent and remittent fevers. Ail-

ments, however, of a less severe nature—such as diarrhœa, dysentery, and various other gastric derangements—have been attributed to their influence; and even when no marked signs of disease can be detected, the inhabitants of such districts often present an enfeebled and pallid appearance. The submerging of meadows, draining of lakes, and digging of canals, have all of them been followed by the development of marsh-diseases, probably on account of the decomposition of vegetable matter which ensues. For the same reason, a long continuance of dry weather, followed by rains, favours the evolution of miasmata. Fortunately, in this country, marsh-diseases have become comparatively rare, though there is no doubt that in low-lying and badly-drained districts the excessive sick-rate which often prevails is in a great measure owing to atmospheric impurities of a marshy nature.

Industrial occupation or trade-processes may be injurious to the workers, or, in so far as they create nuisance, by the evolution of gases or effluvia, they may affect the health of the neighbourhood. It will be convenient, therefore, to summarise this part of the subject under the headings of unhealthy occupations and trade-nuisances.

(1.) *Unhealthy Occupations.*—The great majority of industrial occupations are injurious or otherwise according to the quantity and nature of the dust which is produced. If the particles are soft and rounded as in coal-dust, they are not by any means nearly so injurious to the lung-tissue inhaled as when they are hard, sharp, and angular. According to Dr. Ogle, it is mainly on account of the difference in the character of the dust particles that the workers in coal-mines are far less liable to lung affections than the Cornish miners. Like the coal-miners, they work under conditions of air, vitiated by respiration, combustion of lights, and gunpowder blasting, but they inhale a sharp, angular, and irritant stone-dust particle which

becomes impacted in the air-cells of the lungs, and sets up chronic inflammation in the surrounding tissues. Masons, builders, bricklayers, and quarrymen also suffer to a considerable extent from the inhalation of stone-dust; but as these occupations are carried on in the open air, the effects are not so pronounced.

In the pottery trade, the flat-pressers and scourers at one time suffered to such an extent from the effects of the fine dust inhaled that, according to Dr. Greenhow, almost all of them became eventually asthmatical. Dr. Arlidge, however, in his Milroy lectures, has pointed out that owing to improved ventilation, the mortality from lung diseases has been greatly reduced among this class of workers, though it is still nearly as high as that of the tin-miners. Those of them who are employed in glazing and colouring also suffer from plumbism, and all of them are exposed to the injurious effects of great vicissitudes of temperature.

But of all unhealthy occupations, that of steel-grinding was at one time the most unhealthy. Steel-grinding is divided into dry, wet, and mixed—the most injurious effects attaching to dry grinding. Fans, however, are now commonly used to secure better ventilation, and wet-grinding has become much more general, and as a result of these and other precautionary measures, the average longevity of Sheffield grinders has increased, though phthisis and lung diseases are still very prevalent amongst them.

Cutlers, file-makers, needle, pin, and tool-makers, and workers in cycle factories, who are exposed to metallic dust, also suffer largely from phthisis, pneumonia, and bronchitis. Workers in lead, such as plumbers, painters, and glaziers, in addition to the injurious effects of dust inhalation, are liable to suffer from symptoms of lead-poisoning. File-makers, too, suffer in this respect from

their using a cushion of lead on which to strike their file; while plumbers inhale volatilised oxide of lead and painters the dust of white lead. Lead is also taken into the system when meals are eaten with unwashed hands. There is generally a blue line to be detected on the edge of the gums due to sulphide of lead. Formerly lucifer-match makers suffered frequently from necrosis of the lower jaw caused by phosphorous fumes, but this disease is now averted to a large extent by the use of red amorphous phosphorus.

Brassfounders suffer from "brassfounder's ague," which is characterised by shiverings, tightness of the chest, head-ache, nausea, muscular pains, and feverishness. By some it is supposed that the disease is due to the fumes of zinc-oxide, though it is more probably a form of copper-poisoning, as copper-smiths are liable to be attacked by similar symptoms. The men who suffer most are those who are new to the work, and they lessen the severity of the attack by drinking large quantities of milk. A green line is sometimes to be detected on the lower jaw.

Before electro-plating replaced the old methods, silverers and gilders, who worked with amalgams of gold and silver with mercury, were very liable to mercurialism; while workers in the manufacture of wall-papers and artificial flowers are apt to suffer from symptoms of arsenical poisoning.

Pearl-button makers, and workers in flax or shoddy mills, are liable to be afflicted more or less with bronchial irritation, and many of them with decided lung-disease. Cotton-weavers also suffer very much from the fine dust given off by the "sizing"; and several years ago an inquiry was made by Dr. Buchanan at Todmorden, which revealed the great prevalency of lung-disease, dyspepsia, and permanent epistaxis, amongst this class of operatives. The damp and heated atmosphere in which this class of

operatives work has also a very injurious effect upon health.

Amongst wool-sorters the disease known as anthrax, or malignant pustule, has at times proved very fatal, the poison being conveyed into the system generally by inhalation of the fine dust given off in cleaning the wool, though it also may be conveyed by local inoculation. Two outbreaks have recently been investigated—one by Dr. Russell, Medical Officer of Health for Glasgow; and the other, which occurred at Bradford, by Dr. Spear, Local Government Inspector. (See *Supplements to Local Government Reports* for 1878 and 1880.)

In the following table from the Supplement to the Forty-fifth Annual Report of the Registrar-General, Dr. Ogle has tabulated the comparative mortality from phthisis and other diseases of the respiratory organs which occurred during the ten years 1871-80 among males 25-65 years of age, employed in certain dust-inhaling occupations. Taking 1000 as the comparative mortality figure for all males throughout England at these ages, and Wales as 1000, it will be seen at a glance how greatly the mortality differs in different occupations, and how comparatively small it is among fishermen, who are always in the open air:—

Comparative Mortality among Males 25-65 years of age in certain Dust-inhaling Occupations from phthisis and Diseases of the Respiratory Organs.

Occupations.	Phthisis.	Diseases of the Respiratory Organs.	Phthisis and Diseases of the Respiratory Organs.
Coal Miner	126	202	328
Carpenter, Joiner . . .	204	133	337
Baker, Confectioner . .	212	186	398
Painter, Plumber, Glazier .	246	185	431
Mason, Builder, Bricklayer .	252	201	453
Wood Manufacturer . .	257	205	462
Cotton Manufacturer . .	272	271	543
Quarryman (stone, slate) .	308	274	582
Cutler	371	389	760
File Maker	433	350	783
Earthenware Manufacturer .	473	645	1118
Cornish Miner . . .	690	458	1148
All Males (England and Wales)	220	182	402
Fishermen	108	90	198

In all these industrial employments there is no doubt that the sick-rate and death-rate have both been very materially lessened by promoting ventilation, and by introducing some suitable appliances calculated to protect the workmen from the inhalation of fine dust or noxious fumes. But it has been found over and over again that the workmen themselves often objected to any innovation which appeared to them to interfere with their more immediate comfort; and not a few of them were under the impression that the introduction of any measures tending to prolong life would be followed by such an overstocking of the labour market that the difficulties of procuring a living would be greatly increased. That such shortsightedness will continue to exist amongst certain numbers of the artisan class is only what may be expected. Disease sets in so insidiously and progresses so slowly, the stock of health to start with seems so

ample, and the individual prospect of death so remote, that sanitary rights are neglected and the wrongs quietly endured. No doubt, these widespread evils have been greatly mitigated of late years under the provisions of the Factory and Workshops Acts, but complaints are still made by inspectors that the workmen continue to be very careless about ventilation, and that they have a great aversion to using respirators, even when they know that their use is a safeguard against disease.

It is here worthy of special note that Dr. Arlidge in his "Milroy Lectures," delivered before the College of Physicians in 1889, on "Occupations and Trade in relation to Public Health," has divided the conditions causative of disease as follows:—

Generation of dust { Poisonous.
Non-poisonous.
With heat and moisture. }
Employment of materials of a distinctly poisonous nature.
Evolution of poisonous or injurious vapour.
Excessive temperature.
Evolution of electricity.
Abnormal atmospheric pressure.
Circumstances affecting special senses.
Excessive use, friction, or strain in parts of the body.
Exposure to infectious, contagious, or parasitic diseases.
Extra liability to accidents.

(2.) *Trade Nuisances.*—These embrace the noxious gases or vapours given off in certain trades in which mineral substances are principally dealt with, such as alkali-works, chemical works, brickfields, gasworks, etc., and what may be strictly called effluvium trade nuisances, of animal or vegetable origin.

The principal gas evolved in alkali-works is hydrochloric acid. Its effects on vegetation are very destructive, but with proper care in the condensation of the gas, there does not appear to be any evidence to show that

works of this description are injurious to the health of those living in the neighbourhood.

From chemical works, and especially from those in which gas liquor is utilised for the production of salts of ammonia and other chemical compounds, the injurious gases evolved consist chiefly of sulphuretted hydrogen, ammonium sulphide, and traces of other ammonium compounds. The workmen employed at such works apparently enjoy good health, but when the noxious vapours are not properly consumed by being collected and passed through a furnace, there is no doubt that they do affect the health of the neighbouring inhabitants, though not to any serious extent.

The peculiarly pungent odour of brickfields can be felt at several hundred yards' distance; but though several cases are recorded in which the existence of a nuisance was fully established, none are quoted as having proved that the health of the neighbourhood was affected.

Gasworks are often productive of great nuisance, and probable injury to the health of persons living in the immediate neighbourhood, by the accumulation of lime used for purification, and through want of proper precautions in removing waste ammonial products.

With respect to the effects of trade-nuisances on the general health of the community, a very important inquiry was conducted some few years ago by Dr. Ballard in behalf of the Local Government Board, which is of special interest to sanitary authorities and their officers throughout the country. Dr. Ballard's reports were published in the Supplements to the Local Government Board Reports for 1876, 1877, and 1878, and certainly rank as the most valuable and exhaustive contributions which have hitherto appeared on the subject. The trades embraced in the inquiry included—(1), the keeping of animals; (2), the slaughtering of animals; (3), branches of industry in which animal

substances are principally dealt with; (4), trades in which vegetable matters are principally dealt with; (5), trades in which mineral substances are principally dealt with; and (6), trades in which matters of mixed origin are dealt with. According to Dr. Ballard, the most offensive effluvia are those given off from trade-processes, in which the materials used consist of animal substances—such as gut scraping, manure manufacturing, and the melting of some kinds of fat. The industries which deal with vegetable substances, though often very offensive, do not appear to give rise to effluvia which may be designated disgusting, and are therefore not so liable to be injurious; while those which treat mineral substances are chiefly offensive owing to the irritant gases and other effluvia which are given off. As might be expected, great difficulty was experienced in ascertaining, with any approach to precision, in what respect, and to what extent, these effluvia are injurious to health; but as regards all of them, it has to be noted that in records of proceedings of courts of law, and as the result of Dr. Ballard's inquiries, the particular group of symptoms generally complained of consisted of "loss of appetite, nausea, sometimes actual vomiting, sometimes diarrhœa, headache, giddiness, faintness, and a general sense of depression and *malaise*." Concerning effects of a more definite nature, Dr. Ballard points out that while trade effluvia generally contribute their quota of conditions which render the air of manufacturing towns comparatively insalubrious, there are certain effluvia of septic origin connected with businesses of a specially filthy nature, which are undoubtedly unwholesome, and give rise to filth diseases of various kinds. Other trades, again, in which matters are dealt with which are liable to be infected with specific contagia, cannot fail to be dangerous to persons exposed to such influence; while, as regards trades which give off effluvia consisting of definite chemi-

cal compounds, they are, as a rule, only irritating or injurious in proportion to their degree of concentration. It is often suggested by manufacturers, that because certain effluvia given off by chemical works are in common use as disinfecting agents, they must actually be beneficial to public health; but, as Dr. Ballard points out, this argument is altogether fallacious, inasmuch as such agents are virtually inoperative, unless applied in a degree of concentration far greater than the diluted effluvia often complained of outside the works.

In other respects, Dr. Ballard's reports are especially valuable, because they point out in detail not only the trades or trade-processes which are most complained of as offensive, but they explain the methods in use, or which may be devised, for preventing or minimising the nuisances arising from them. This part of the subject, however, will be more fully treated in the concluding chapter on the Duties of Medical Officers of Health.

CHAPTER IV

VENTILATION AND WARMING

These two subjects may be conveniently treated under the following sections :—

I. The Amount of Fresh Air required.
II. The Necessary Amount of Cubic Space.
III. Natural Ventilation.
IV. Artificial Ventilation and Warming.

Section I.—The Amount of Fresh Air required.

As the air contained in an inhabited room cannot, under the most favourable circumstances, be maintained in as pure a condition as the external air, the object of ventilation is to reduce the impurities of respiration to such an extent that continued inhalation of them will not be detrimental to health. While this can only be effected by a constant supply of fresh air, it is evident that the quantity required will very much depend on the amount of impurities which may be allowed to accumulate in respired air without proving injurious. The first point, therefore, which has to be determined is the limit of maximum impurity consistent with the maintenance of perfect health. It has already been shown that the amount of carbonic acid in air vitiated by respiration is a tolerably reliable index to the other impurities; and hence the question resolves itself into this,—What amount

of CO_2 shall be accepted as the standard of permissible maximum impurity? After numerous experiments, and a most extended inquiry, the late Dr. Parkes gave it as his opinion that, allowing 0·4 volume as the average amount of CO_2 in 1000 volumes of air, this standard ought not to exceed 0·6 per 1000 volumes; because, when this ratio is exceeded, the organic impurities, as a rule, become perceptible to the senses. With a ratio of 0·8, 0·9, or 1 per 1000 volumes, the air smells stuffy and close, and beyond this it becomes foul and offensive.

Perhaps there is no class of buildings which present better opportunities for arriving at an approximate and practical solution of this problem than prisons; and it may prove of some service if I record briefly the results of some experiments which I had a share in conducting several years ago, and which are strongly corroborative of Dr. Parkes's views. In one of the English convict prisons one-half the prisoners are kept in separate confinement, except when at exercise; the other half are confined in their cells only during the night and when at meals. The cubic space and ventilating arrangements in the part of the prison occupied by the former were such that the average ratio of CO_2, after a series of observations made at different hours of the night, was found to be 0·720 per 1000 volumes; while in the part of the prison occupied by the latter the cubic space was much smaller, and the average amount of CO_2 was as high as 1·044 per 1000 volumes. The same number of observations were made in both parts of the prison at the same hours during the night-time, so that a strictly fair comparison could be drawn. Now, a careful inspection of the two classes of prisoners resulted in showing that whereas the former were well nourished and healthy-looking, the latter presented a somewhat less

robust and more pallid appearance; and after eliminating every source of error, this difference in appearance could only be accounted for by the difference in the amount of impurities contained in the respired air of both parts of the prison.

I have had many other opportunities of examining into this point, and would say, in general, that when the CO_2 does not exceed 0·8 per 1000 volumes, no *tangible* injurious effects upon the health can be detected; but when it reaches 1 per 1000 volumes, the cumulative effects manifest themselves in producing a pallid, dyspeptic, appearance, and make themselves felt, in numerous instances, in general *malaise* of a morning, slightly coated tongue, nasty taste in the mouth, and headache.

The desirability of adopting Dr. Parkes's estimate as the standard of maximum impurity is also borne out by the observations and experiments of such eminent authorities as Professor Pettenkofer of Munich, Dr. Angus Smith, and Dr. de Chaumont. "We all avoid," wrote Dr. Smith, "an atmosphere containing 0·1 per cent of carbonic acid in crowded rooms; and the experience of civilised men is, that it is not only odious but unwholesome. When people speak of good ventilation, they mean, without knowing it, air with less than 0·07 per cent of carbonic acid. We must not conclude that because the quantity of carbonic acid is small, the effect is small; the conclusion is rather that minute changes in the amount of this gas are indications of occurrences of the highest importance."—(*Air and Rain.*)

Assuming, then, that 0·6 CO_2 per 1000 volumes is accepted as the standard of maximum impurity, and remembering that an adult at rest exhales on the average 0·6 cubic feet of CO_2 per hour, the next question comes to be—How much fresh air must be supplied per head per hour, in order that the respired air should not con-

tain impurities in excess of this standard? Taking the initial CO_2 contained in the atmosphere at the normal ratio of 0·4 per 1000 volumes, the permissible limit of respiratory impurity is thus seen to be 0·2 CO_2 per 1000 cubic feet, or 0·0002 per cubic foot. With these data it is evident that it will require 3000 cubic feet of fresh air per head per hour to prevent the contained air in a room from exceeding 0·6 CO_2 per 1000, because $0{\cdot}0002 \times 3000 = 0{\cdot}6$, the amount of CO_2 exhaled by each individual per hour. This is expressed in the following equation, in which e represents the amount of CO_2 exhaled, r the respiratory impurity per cubic foot of air, and d the delivery of fresh air required, or amount available, thus:—

$$\frac{e}{r} = d, \text{ then } d = \frac{0{\cdot}6}{0{\cdot}0002} = 3000;$$

or, $\frac{0{\cdot}6}{0{\cdot}2} = 3 =$ number of *thousands* of cubic feet of air required per head per hour. In any given problem, if e and r are known we can find d, and if d and e are known we can find r. Thus, we will suppose that the limit of total impurity is fixed at 0·7 CO_2 per 1000 volumes, then $\frac{0{\cdot}6}{0{\cdot}7 - 0{\cdot}4} \times 1000 = 2000$ cubic feet, the amount of fresh air which would be required per head per hour. Or, to take the following examples:—

1. Suppose a room of 2000 cubic feet capacity is occupied by six persons for four hours, what will be the total amount of CO_2 per 1000 volumes at the end of the time, assuming that 12,000 cubic feet of air per hour have been supplied?

In this problem d, the total amount of air available for breathing by the six persons in the four hours, is 2000 cubic feet (the cubic space of the room) $+ 12{,}000$ cubic feet $\times 4$ (the amount of air supplied in four hours) $= 50{,}000$ cubic feet; while $e = 0{\cdot}6 \times 6 \times 4$

$=14 \cdot 4$ cubic feet, the total amount of CO_2 expired. It is now required to find r.

$$d=\frac{e}{r} \text{ or } r=\frac{e}{d}=\frac{14 \cdot 4}{50,000}=0 \cdot 000288,$$

or the respiratory impurity is $0 \cdot 288$ parts per 1000, and the total impurity will be $0 \cdot 288+0 \cdot 4=0 \cdot 688$ CO_2 per 1000 volumes.

2. How much fresh air per hour is required for a hall containing 300 persons in order that the air in the hall may not yield more than $0 \cdot 8$ CO_2 of total impurity per 1000 volumes?

$$\text{Here } r=0 \cdot 8-0 \cdot 4=0 \cdot 4,$$
$$\text{and } e=0 \cdot 6 \times 300=180,$$
$$\text{then } d=\frac{180}{0 \cdot 4} \times 1000=450,000 \text{ cubic feet,}$$

or 1500 cubic feet per head.

If the cubic contents of the occupied space are given, the amount of CO_2 in the contained air must be taken into account, and this will lessen the amount of fresh air required at the close of the first hour. Thus, in the above example, we will suppose that the size of the hall is 200,000 cubic feet, then the amount actually required during the first hour would be $450,000-200,000 =250,000$ or $833 \cdot 3$ cubic feet per head. After the first hour, to maintain the CO_2 at $0 \cdot 8$, the total amount of 450,000 cubic feet of fresh air would be required. In all these calculations it is assumed that an equal volume of impure air is removed to make room for the entrance of the fresh air.

The results obtained by actual experiment accord so closely with those which have been deduced from calculation that some of them may be fitly quoted here. The following are given by Dr. de Chaumont (*Edin. Med. Journal,* 1867) as selections from a series of observations made at Aldershot camp:—In a room containing 18 men, with a supply of 1200 cubic feet of fresh

air per head per hour, the CO_2 was found to be ·855 per 1000 volumes; in another containing 13 men, with a supply of about 1700 cubic feet, it was ·759 per 1000 volumes; and in a third, containing 22 men, and with a supply of about 765 cubic feet per head per hour, it amounted to 1·2 per 1000 volumes. All these observations were made at the same hour (5 A.M.), and in barrack-rooms ventilated on the plan proposed by the Barrack Commissioners in 1861, which provided that at least 1200 cubic feet of fresh air should be delivered per head per hour.

But there are other circumstances in which it is necessary to augment the delivery of fresh air in order to maintain the standard of purity. When lights are used, for example, and the products of combustion are allowed to pass into a room, a large supply is required to keep the contained air sufficiently diluted. Thus it is found that 1 cubic foot of coal gas destroys the oxygen of 8 cubic feet of air in combustion, and produces about 2 cubic feet of CO_2, besides other impurities. As a common gas-burner burns about 3 cubic feet of gas per hour, the CO_2 produced amounts to about 6 cubic feet, or ten times the amount exhaled by an adult at rest. Then, again, it should be noted that, inasmuch as a man exhales more CO_2 and other respiratory impurities during work than when at rest, the amount of fresh air per head per hour supplied to workshops and factories should be considerably in excess. Assuming that at light work an adult exhales 0·95 cubic feet CO_2 per hour, and at hard work 1·96, then the fresh air delivery for the former should be 4750 cubic feet per hour, and for the latter 9800 cubic feet.

It is evident also that the sick require a larger supply of fresh air than the healthy, for it has been found that when as much as 3500 to 3700 cubic feet have been

delivered per patient per hour, hospital wards have not been free from offensive smell, owing to the greater amount of organic impurities given off.

Carnelly, Haldane, and Anderson, adopting a threefold standard impurity of carbonic acid, organic matter, and microbes, propose that instead of 0·6 carbonic acid per 1000, the permissible limit should be 1·0 for houses and 1·3 for schools.

Section II.—Cubic Space.

This should be large enough to permit the passage of 3000 cubic feet of air per head per hour, without producing perceptible draughts. If the cubic space per head is small, the renewal of air will necessarily be much more frequent than when it is large. Thus, with a space of 100 cubic feet, the contained air must be renewed thirty times per hour, in order that the standard amount be supplied; whereas, with one of 1000 cubic feet, only three renewals of air would be required. What, then, is the minimum amount of cubic space through which the standard amount of fresh air can be passed without perceptible movement? Professor Pettenkofer has answered this question experimentally, and has found that by means of artificial ventilation, and with the aid of the best mechanical contrivances, the air in a chamber of 424 cubic feet can be renewed six times per hour without creating any appreciable air-currents. No doubt, therefore, such a space as this, or one somewhat smaller, can be efficiently ventilated, provided that perfect artificial means be employed, and the air warmed; but with natural ventilation this becomes impossible. Indeed, a change of air three or four times per hour is all that can be borne in this country without discomfort, and this would require an initial air-space of 750 to 1000 cubic feet. Practically speaking,

the difficulties of ventilating small spaces efficiently are due not so much to the movement of the contained air as to the relative position of the inlets, these being of necessity so near the person that the draughts which are produced become disagreeable or injurious. This is well exemplified in the case of prisons. In hard-labour prisons, where convicts are confined in their cells only during the hours of rest, the cell-space seldom exceeds 200 cubic feet. The consequence is that in cold or inclement weather these draughts become so unpleasant that many of the prisoners block up the inlets as effectually as they can, and of course obstruct the ventilation to a serious extent. So far as my experience goes, it is difficult, even with the aid of a well-devised plan of ventilation, to supply the necessary amount of fresh air per head per hour without creating perceptible draughts occasionally, if the space be less than 600 cubic feet. I have further satisfied myself that with the same artificial appliances and arrangements, the air contained in small occupied spaces becomes much more impure than in large spaces. For example, in the experiments already alluded to in the last chapter, the cell-space in one-half the prison was 210 cubic feet, in the other half it was 614. The same means for extracting the foul air through flues leading from every cell to a foul-air extraction shaft, in which a furnace was kept burning to produce a constant draught, were common to both parts of the building. Moreover, the fresh-air inlets were more amply provided for in the small than in the large cells, and yet the average amount of carbonic acid, after a series of observations, was found to be 1·044 per 1000 volumes in the former, and only ·720 in the latter.

These results accord very closely with those which have been recently obtained by Carnelly, Haldane, and Anderson, as will be seen from the following table, which

gives in addition to the CO_2 the relative amount of organic matter and number of microbes per litre :—

Average Results of Analyses of Air in Sleeping Rooms between 12.30 and 4.30 a.m. (*Carnelly, Haldane, and Anderson*).

Cubic Feet per Head.	Temperature (Fahrenheit).	Carbonic Acid per 1000 vols.	Organic Matter (vols. of Oxygen required per million vols. of air).	Microbes per litre.
100–180 . .	55°	1·15	15·1	80
180–260 . .	54°	1·07	15·1	49
260–340 . .	53°	1·03	11·8	32
340–500 . .	57°	0·92	8·4	42
500–1000 . .	54°	0·86	5·6	6
1000–2500 . .	53°	0·67	3·9	9

With a small cubic space it is impossible to obtain uniform diffusion of the contained air, if a large amount of fresh air is supplied, because between inlet and outlet a direct current is established, and a considerable quantity of air passes right through without being utilised. Again, it is evident that if the ventilation is impeded or becomes arrested, impurities will collect with far greater rapidity in a small than in a large space, and this of itself is a great argument in favour of the adoption of an ample cubic space as a basis.

With ordinary means of ventilation (artificial excluded) both Dr. Parkes and Dr. de Chaumont have contended that the cubic space for a healthy adult ought at least to be 1000 feet. It is true this is very much in excess of what is generally obtained. In the crowded dwellings of the poorer classes it seldom reaches 200 to 250 cubic feet; but then the disastrous effects declare themselves but too clearly in the increased rate of mortality. In

metropolitan lodging-houses the allowance per head is as low as 240 cubic feet; in the Dublin registered lodging-houses it is 300; in workhouse dormitories it is 300; while in Board Schools the Education Department require only 100 cubic feet as a minimum. The Barrack Commissioners, on the other hand, recommended a minimum space of 600 cubic feet for soldiers, insisting at the same time that the air should be renewed at least twice every hour.

For further remarks on cubic space in hospitals, see Chapter on Hospitals.

In summing up this part of the subject, the following may be accepted as the standard conditions necessary for the requirements of *perfect* health :—

1. That the limit of maximum impurity of air vitiated by respiration ought not to exceed 0·6 carbonic acid per 1000 volumes.

2. That to ensure the maintenance of this standard under ordinary circumstances, 3000 cubic feet of pure air must be supplied per head per hour.

3. That for this purpose, and with ordinary means of ventilation, a space of at least 1000 cubic feet should be allowed per head in buildings permanently occupied.

It may be objected that these conditions aim at too high a standard, and that in general they are seldom met with; but it must be remembered that they are based on a firm foundation of facts, and that, though it may not be possible to prove in all cases that bad effects result from a neglect of them, it does not follow that such bad effects may not have been produced. In a country like this, with a climate so variable, the cubic space allowance is a most important element in any scheme of ventilation. It should be ample enough to permit of a sufficient supply of fresh air without creating injurious draughts, and yet not too large to interfere with the maintenance

of a sufficient and equable temperature during cold weather. Where artificial ventilation is provided, and when the fresh air can be heated before entering, it may be as low as 400 cubic feet, but even then the ventilating arrangements must be much more perfect than they usually are. In the case of healthy adults, such as soldiers and prisoners, the standard allowance may also be considerably lessened, if care be taken that the free entrance of fresh air at all hours and in sufficient quantity shall not be interfered with. Unfortunately the question of cubic space is a question of large outlay, and hence the desire to economise tends to curtail the minimum not within safe limits, but within limits that will not be attended with glaring injurious effects.

Then, too, it should be noted that an essential item in cubic space is the superficial area or floor space which is necessary for each individual. If the height of the room is over 12 or 14 feet, excess in this direction does not compensate for diminished floor space, because it is found that the organic impurities of respiration tend to accumulate in the lower strata of the contained air. In metropolitan lodging-houses the superficial space allowed for each individual is 30 feet, and in hospitals the minimum is about 90, while in Board Schools it is fixed at the exceedingly low floor space of 8 square feet. Generally speaking, the minimum floor space should not be less than one-twelfth of the cubic space.

For horses 1200 to 1800 cubic feet, with 100 to 120 square feet of floor space, should be allowed; and Dr. Ballard has recommended that dairy cattle should have at least 1000 cubic feet per cow. Very often, however, the cubic space does not exceed half this amount.

SECTION III.—NATURAL VENTILATION

Natural ventilation is carried on by the agency of natural forces, such as gaseous diffusion and movements of air produced by inequalities of temperature.

1. *Diffusion.*—The force of gaseous diffusion, upon which the uniform constitution of the atmosphere itself depends, is manifestly inadequate as a ventilating power. It operates chiefly in producing, as has been already stated, a tolerably equal distribution of the gaseous products of respiration and combustion throughout the air contained in a room, but aids only to a very slight extent the removal of these impurities from the room, while it is altogether inoperative as regards the removal of organic impurities.

2. *Movements of Air produced by Inequalities of Temperature.*—As common air is subject, like other gases, to the laws of gaseous expansion, it undergoes a certain increase or diminution in bulk, according as it is heated or cooled. Warm air is therefore lighter than cold air, and hence a constant interchange goes on through every available opening, whenever there is any difference between the outside and inside temperature. The contained air on being heated expands, a portion of it escapes, and the colder outside air rushes in to establish the equilibrium. Indeed, the movements produced by inequality in weight of masses of air at different temperatures are the natural means by which ordinary ventilation of houses is chiefly carried on in this climate, and especially during the colder months of the year. The law which governs these movements will, however, be more fitly explained later on.

But in addition to the slighter currents, the movements of the external air, or winds, greatly assist ventilation by their perflating or aspirating action. Perflation is best exemplified in the cross-ventilation which takes

place through opposite windows when opened. This is by far the readiest means which can be adopted for removing speedily and effectually aerial impurities from a room, but it cannot always be depended on, on account of the uncertainty of the rate of movement; for if the air be stagnant, there can be little or no perflation, while, on the other hand, if the rapidity of movement is great, perflation becomes insupportable in consequence of the draughts produced. A current of cold air moving at the rate of five or six feet per second becomes unbearable. In spite of this objection, however, cross-ventilation should always be provided for whenever it is practicable, and especially in large rooms, such as hospital wards.

The aspirating action of the wind produces up-currents through chimneys and air-shafts, by creating a partial vacuum in them, which is constantly being filled by the column of air from beneath. The mechanical arrangements which have been proposed or adopted to facilitate the action of these natural ventilating powers are so numerous and varied, that only a brief mention of the more important of them can be given. To utilise the perflating force of the wind, opposite windows should be made to open from the top and bottom, and to obviate the unpleasantness arising from draughts, some such arrangements as the following have been recommended:—

(1.) By having the window so constructed that the top slopes inward when it is opened, so that the entering current of air impinges against the ceiling. If the window is large, as in churches or schools, only a section of the upper part may be made to open in this way.

(2.) By substituting a glass louvre for the top centre pane.

(3.) By having some of the panes doubled; the outer with an open space at the lower edges; the inner with an open space of the same size at their upper edges. The

air on entering is thus made to pass upward between the panes.

(4.) By having some of the panes made of perforated glass, as in Potts's plan.

(5.) By raising the lower sash of the window two or three inches and filling in the opening under the bottom rail with a piece of wood as proposed by Mr. P. H. Bird. This leaves a corresponding space between the meeting rails in the middle of the window through which the entering current of fresh air is directed towards the ceiling.

(6.) By having a part of a pane to open or shut at will by a spring arrangement, as in Boyle's ventilator.

(7.) By fixing a fine wire screen to the top of the window, which unfolds when the window is pulled down, and folds up when the window is shut. As the fine meshes of the screen are apt to become clogged up with dust, this plan is objectionable, except when the windows are of low elevation, as in attic rooms.

Other outlets and inlets may be provided by inserting perforated bricks in the walls near the ceiling. One of the best inlets is the Sheringham valve, which closes at will by a balanced weight. It slopes inwards and upwards when open, so that the entering current of air, which first passes through a perforated brick or grating, is directed towards the ceiling.

Currall's patent ventilators, supplied by Tonks and Sons, Birmingham, are easily applied, and appear to work very well. The inlet is made suitable for doors, windows, and walls, and is so arranged as to obviate disagreeable draughts, while the outlet may be inserted in the chimney-breast or an outer wall. Ellison's conical bricks, which are pierced with conical holes, are so constructed as to admit outer air without creating perceptible draught.

In some cases cross-ventilation can be tolerably well maintained, independently of opposite windows, by means

of transverse ventilating boxes or tubes, situated at regular distances, and in close proximity to the ceiling. These boxes or tubes extend from wall to wall, and communicate with the external air at either end by air-bricks. The sides are made of perforated zinc, and there is a diaphragm in the centre of each, to prevent the wind from blowing right through. According to the direction of the wind, one-half the tube becomes an inlet for fresh air, which falls gently into the room through the perforated zinc, while the other half becomes an outlet for the vitiated air.

This plan does very well for large hospital wards having an internal corridor running along one side. Inner rooms can also be supplied with a certain amount of cross-ventilation in the same way.

Another plan which has been very much lauded within the past few years is that which is associated with the name of Mr. Tobin of Leeds. It consists in introducing fresh air by means of vertical tubes carried for a certain distance up the walls of the room, so as to obviate any discomfort arising from down-draught. In rooms or class-rooms with windows only on one side, this is a very convenient method of improving the ventilation. A similar method of ventilating by pipes, introduced by Mr. Shorland of Manchester, has also been found to work very well.

The aspirating power of the wind is frequently utilised by placing cowls on the tops of air-flues or chimneys. If not made to rotate according to the direction of the wind by means of vanes, they should be so constructed as to prevent the entrance of rain. Among cowls which have received favourable notice may be mentioned the various cowls patented by Kite and Co., Banner, Boyle, Buchan, and Ellison.

According to experiments conducted some years ago by a Committee of the Sanitary Institute at Kew Gardens,

the great majority of cowls tested showed no superiority in aspirating power over the simple open tube.

Louvres are sometimes used instead of cowls, but, unless specially constructed, they are apt to let in the rain and permit down-draughts.

In several plans of natural ventilation the perflating and aspirating powers of the wind are both taken advantage of. Thus, by a suitable arrangement of shafts and cowls, this mode of natural ventilation can be made to do excellent service in ships, and in buildings so constructed or situated that other ventilating means will not suffice. It was on this principle that Dr. Arnott ventilated the Field Lane Ragged School so successfully. The entrance and exit tubes were both fitted with cowls, the one set turning away from the wind, the other facing the wind. The latter also were of a higher elevation than the former, in order to increase their extractive power.

A system of natural ventilation, well suited for large rooms, and which has been highly spoken of by Mr. Robson, architect to the London School Board, is that devised by Mr. Potts. It consists of a hollow metal cornice running continuously round the room, and divided longitudinally throughout its whole length into two separate channels, by a plate attached to the lower one. The fresh air is admitted through openings in the wall into the lower channel, and falls imperceptibly into the room through numerous perforations. The upper channel communicates either with the smoke-flue or other air-shaft, and receives the vitiated air through a series of small openings similar to those of the lower channel. As the fresh air, being colder, descends by its own gravity, and the vitiated air, being warmer, rises to the highest point, there is no doubt that the principles of the system are correct. Mr. Robson strongly recommends it for facility of application to buildings originally erected

without proper provision for ventilation, for sightliness, economy of first cost, and self-acting properties.

Another plan, which has been found to work well in schools, has been proposed by Mr. H. Varley. A perforated zinc tube, communicating with the external air, passes along the cornice of three sides of the room, while on the fourth side another perforated tube is connected with the chimney, which acts as the extraction-shaft.

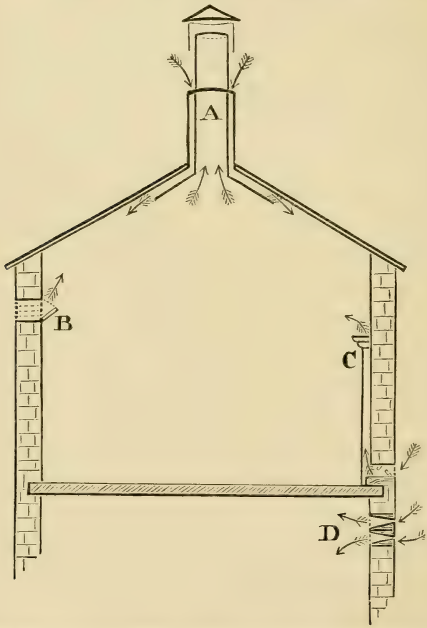


Fig. 1.—A, McKinnell's Ventilator; B, Sheringham Valve; C, Tobin's Tube with water tray; D, Ellison's Conical Brick Ventilators.

The plan proposed by Mr. McKinnell, though it belongs to the same category, is less widely applicable than either of these two, because it is only suited for one-storied buildings or upper rooms. It consists of two hollow cylinders, one within the other, and of such relative

calibre that the transverse area between the tubes is equal to the sectional area of the inner tube. The inner tube is of slightly higher elevation than the outer, and acts as the outlet. The fresh air enters between the tubes, and is thrown up towards the ceiling by means of a horizontal flange surrounding the lower margin of the inner tube. Both tubes should be situated in the centre of the ceiling or roof. Some of these ventilating arrangements and appliances are illustrated in Fig. 1, though it need hardly be pointed out that they would not all be required to ventilate the same room.

SECTION IV

ARTIFICIAL VENTILATION, WARMING, AND LIGHTING

Artificial ventilation is carried on either by forcing the air into and through a room (propulsion), or by drawing the air out of a room (extraction). These two methods are also spoken of as the *plenum* and *vacuum* systems of ventilation.

Although it may appear to be an easy matter to ventilate a room without any regard to temperature, or to warm it without providing for a due supply of fresh air, it becomes a problem of very considerable difficulty to ensure, in all cases, that both the ventilation and warming shall be efficient and satisfactory. This difficulty depends in a great measure on the fact that the means employed in ventilating necessarily dissipate and carry off a certain quantity of the heat which should be utilised for warming purposes.

The heat used for warming is propagated by radiation, conduction, or convection, or a combination of two or all three of these methods. The heat emitted by an incandescent fire is chiefly radiant, though part of it is reflected

from walls and articles of furniture, which in becoming warmed assist in propagating the heat by conduction. Hot water pipes and close stoves, on the other hand, warm the air by convection, but if their surfaces are polished they also give out a considerable amount of radiant heat. Convection depends on the mobility of gases and fluids, which on being heated expand and rise, the displaced and warmed particles being continuously replaced by the colder and heavier particles. A circulation of the air or water is thus kept up and the whole mass soon becomes warmed. Conduction of heat takes place through all solids, and to a certain extent through liquids and gases, but these are in themselves very bad conductors. Metals are better conductors than stone, and some metals are far better conductors than others. Copper, for example, is more than four times as efficient as iron for transmitting heat from any source to the surrounding medium, and were it not for its higher price it would form the best material for stoves, hot-water pipes, steam pipes, or warm air pipes. Porous and felty materials are in themselves bad conductors, and are therefore very useful when it is desired to impede the loss or escape of heat. Thus a boiler may be encased in felt, while the hot-water pipes may be of polished metal to aid the emission of heat by conduction and radiation.

Radiant heat passes through the air without warming it, and its intensity is inversely as the square of the distance of the heated object from the source of the heat. Thus two similar objects at distances of three and four feet from an open fire-place would receive heat in the proportions respectively of 16 to 9.

In this country artificial ventilation and warming are usually provided for by open fire-places. The heat is obtained by radiation from the incandescent fire, and by radiation and reflection from the different parts of the

grate, furniture, etc., while ventilation is carried on by the constant current of heated air rushing up the chimney. Even when there is no fire, the chimney acts as a very efficient ventilating shaft.

When doors and windows are closed and a fire kept burning, the fresh air enters the room through every chink and opening, provided there are no special inlets. Hence it follows that the more closely doors and windows are made to fit, so much greater are the obstacles to the entrance of fresh air. When this is the case, the fire feeds itself by establishing a double current in the chimney, the downward current entering the room in puffs, and carrying with it clouds of smoke. Generally, however, doors and windows are not made to fit so closely that a sufficient amount of air for feeding the fire cannot enter, and under ordinary circumstances the supply and circulation are somewhat as follows:—The greater portion of the fresh air enters beneath the door, and is drawn along the floor towards the fire-place. It is warmed to a certain extent during its course by the radiating heat of the fire, and when it approaches the fire-place part of it rushes up the chimney along with the smoke, while the other part ascends towards the ceiling, and after ascending passes along the ceiling towards the opposite end of the room. During its progress it becomes cooled, and therefore descends to be again drawn towards the fire-place with a fresh supply from beneath the door and through the chinks of the window-frames, if they are not air-tight. As the air which thus enters is usually cold air, it is evident that the room is insufficiently or unequally warmed and badly ventilated. At the end of the room opposite the fire-place the temperature is below the average, and the cold current near the floor chills the feet. Moreover, the air is not properly diffused, so that although a sufficient supply may actually be entering,

impurities are apt to accumulate in the centre and upper parts of the room.

The position of the fire-place is likewise a matter of considerable importance. The practice followed by most builders is to place fire-places in external walls, by which means a large amount of heat is wasted. If, on the other hand, they are grouped in the centre of the house, more heat is utilised, and greater equability of the inside temperature is maintained.

With ordinary fire-places it is found that nearly seven-eighths of the heat generated passes up the chimney, along with a quantity of air varying from 6000 to 20,000 cubic feet per hour. While, therefore, a single chimney will on the average act as an efficient ventilating shaft for a room containing from three to six or more persons, it is quite clear that by far the greatest portion of the fuel is wasted as a warming agent. The structure of the fire-place thus becomes a matter of special importance, because not only may the fuel be economised to a considerable extent, but by certain mechanical arrangements an equable temperature may be maintained and the air warmed before it enters the room.

Of the fire-places adapted to meet these requirements, one of the best and first devised is the ventilating grate designed by Sir Douglas Galton (see Figs. 2, 3, 4, and 5). It provides for an air-chamber at the back, in which the fresh air is heated before it enters the room. If the fire-place be built in an external wall, the inlet for fresh air may be situated immediately behind, but if in an inner wall, a channel communicating with the external air by perforated bricks or gratings, and passing beneath the flooring or behind the skirting, must be laid. On the back of the stove broad iron flanges are cast, so as to present as large a heating surface as possible. These project backwards into the chamber, and this heating

surface is further supplemented by the smoke flue, also of iron, which passes through the chamber, and is made continuous with the chimney. The fresh air heated in this manner enters the room by a louvred opening situated between the fire-place and ceiling, or by two such

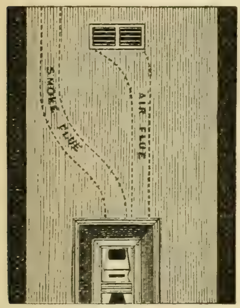


Fig. 2.—Elevation, showing air and smoke flues.

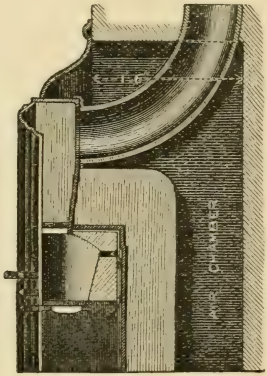


Fig. 3.—Section of grate.

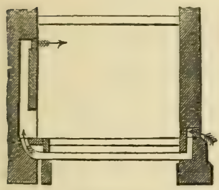


Fig. 4.—Section of a room showing air-duct and flues.

Fig. 5.—Plan of grate and air-chamber.

(After Galton.)

openings, one at either side of the chimney-breast. The grate itself is so constructed that the greatest amount of obtainable reflected heat is given off, and a more perfect combustion of the smoke effected than with an ordinary grate. The stoves are of different designs and sizes, to suit existing chimney-openings and different sized rooms. They have the same cheerful aspect as the ordinary grate, and produce the same degree of warmth in a room with a third of the quantity of fuel; besides, the temperature

of the room is much more equable, and unpleasant draughts of cold air are avoided. Several varieties of ventilating grates, but all of them constructed on the same principles as the Galton grate, have been produced from time to time, but only one or two need be mentioned. In Boyle's ventilating grate, for example, the heated air enters the room through a transverse fenestrated opening extending along the top of the grate. In Shorland's patent Manchester grate, which has been highly spoken of, the warmed outside air is made to enter the room through the shelf of the chimney-piece, and by means of special flues it can be conveyed to bedrooms above. Kitchen stoves have also been constructed on the same principle, and ventilating grates suited for the centre of halls or wards. The smoke flue of the latter is made to pass out under the flooring, as well as the fresh-air entrance channel.

But in addition to their warming properties, various grates have been specially devised to economise fuel and consume their own smoke. The vast majority of grates at present in use are constructed on wrong principles by allowing the cold air to rush through the centre of the fire, thus causing rapid consumption of the fuel, and sending the warmth along with the half-burned gases up the chimney. In order to economise fuel it is necessary to cut off this stream of cold air which passes through the bottom of the grate;—an arrangement which is carried out in all grates made with solid fire-brick bottoms, after the pattern of the Parson's, Abbotsford, or Kyrle grates. But, as Mr. Pridgin Teale has so clearly pointed out in a small brochure on economy of coal, the same results can be obtained by closing up the open chamber under the grate by means of a close-fitting shield or door, which can be made by any blacksmith or ironmonger. Indeed, according to Mr. Teale's experiments, grates provided with

these shields, or "economisers" as he calls them, answer better than those with solid fire-brick bottoms, and he gives some excellent rules regarding the construction or alteration of fire-places, which are of such general application that they may be fitly quoted here:—"1. Use as much fire-brick and as little iron as possible. 2. The back and sides of the fire-place should be made of fire-brick. 3. The back of the fire-place should lean or arch over the fire. 4. The bottom of the fire or grating should be deep from before backwards (not less than 9 inches for a small room). 5. The slits in the grating should be narrow. 6. The bars in front should be narrow. 7. The chamber beneath the fire should be closed in front by a shield or 'economiser.' In lighting the fire it is well to draw away the economiser for a short time until the fire is well started. If an 'economiser' is not used, considerable saving of fuel may be effected by having an iron plate made to fit the bottom of the grate and laid on the bars."

Great improvements, too, have recently been made in close stoves and kitcheners, both as regards economy of fuel and smoke abatement, while gas-cooking stoves are coming into much more general use, especially during the summer months. There are also several very admirable gas-ventilating stoves, such as the well-known Calorigen stove invented by Mr. George, and Dr. Bond's Euthermic Ventilating Stove. For warming and ventilating bedrooms, the Thermic Ventilator devised by Mr. Lawson Tait of Birmingham may be mentioned as a cheap and effective arrangement.

The great objection to many of the commoner kinds of stoves depends on the fact that their over-heated surfaces dry the air to a very unwholesome extent, even when the fresh air is conveyed by a special entrance channel. Numbers of them, however, are put up without

providing any such channel, so that the air not only becomes dry and burnt, but exceedingly close and unpleasant, and when cast-iron stoves are used carbonic oxide gas may be evolved. Evaporating dishes placed on the stoves will assist in keeping the air from becoming too dry, or painting the iron surface with a solution of silica, as suggested by Dr. Bond, may prevent the evolution of carbonic oxide; but it is much preferable, and in the long run more economical, to have a good ventilating stove erected in the first instance. Some of the best kind of ventilating grates or stoves are made almost entirely of fire-clay and porcelain. Indeed, of whatever material the outside casing may be, all stoves should be lined with fire-clay.

For ventilating stoves it is necessary that the fresh-air channels should be removed from all sources of contamination, such as drains, closets, stables, etc.; and it is advisable to protect the external openings by perforated bricks or gratings. The size of the stove and the sectional area of the air-channel must of course be regulated by the size of the space which is to be warmed and ventilated.

Stove smoke flues may be either ascending or descending, but in the latter case a pilot-stove or rarefier ought to be fixed at the base of the upright chimney which receives the flue, otherwise the draught may prove faulty. Soot doors should be provided at all the bends, wherever practicable.

With the ordinary grate the ventilation of a room may be very greatly improved by providing an entrance into the chimney near the ceiling, and to prevent reflux of smoke, the opening should be valved, as in Dr. Arnott's chimney ventilator, or Crossley's noiseless ventilators. One or more openings for the entrance of fresh air could be obtained by inserting perforated bricks or Sheringham

valves in the outer walls, also near the ceiling, but at a distance from the fire-place, or by adopting one or other of the several contrivances mentioned in the previous section. Indeed, the mistake which is common to the great majority of houses consists in providing an outlet, generally the chimney, and neglecting to provide inlets, whereas the essential principle of ventilating demands that there shall be at least two openings, one of which shall act as an inlet, and the other as an outlet, according to circumstances.

Instead of an opening leading directly into the chimney for an outlet, a much better plan is to have a flue running alongside the chimney, the entrance to the flue being situated near the ceiling. The hot air in the chimney warms the flue, and there is thus a constant upward current established without any risk of reflux of smoke. But this is an arrangement which can only be attended to in the original plan of a building; it cannot be applied as an improvement afterwards.

Some architects recommend that all the rooms in a well-constructed house should be supplied with warm air from the hall and staircase. In Mr. Ritchie's plan the air is heated to about 70° Fahr., and enters the various rooms through longitudinal openings over each door. After being diffused through the rooms, it then passes up the chimneys and through flues reaching from the ceiling to the wall-heads under the roof.

Somewhat similar to this is the plan devised some time ago by Drs. Drysdale and Hayward of Liverpool. The fresh air, warmed by a coil of hot-water pipes in the basement, is admitted into a central hall containing the staircase and separate landings, from which it enters the several rooms by suitable openings supplied by valves, and from these again it is conveyed to special outlets in the ceilings, converging to a foul-air chamber under the

roof. From this foul-air chamber there is a downcast shaft communicating with the kitchen fire, which is thus made to act as an extraction-furnace.

With regard to these and other complicated methods of house-ventilation, it has to be pointed out that no system is to be commended which dispenses with the opening of windows occasionally in order to secure thorough perflation. No doubt, it adds greatly to the comfort of a house if the air in the hall is warmed, and it will also add greatly to comfort if the air thus warmed can be introduced into the rooms by suitable openings; but even in winter the windows should be thrown open for a brief period at least every morning, and in summer, window-ventilation should be chiefly depended on, and the entrance-hall, if louvred in the roof, would act as an extraction-shaft.

Large and compact buildings, such as hospitals, asylums, and prisons, can be very efficiently warmed and ventilated by a suitable arrangement of steam-coils or hot-water pipes. The fresh air, as it enters through openings properly distributed throughout the building, is warmed by passing over the pipes, while the vitiated air may be extracted by means of other coils of heated pipes situated in extraction-shafts,—a plan which is adopted in the Hôpital Lariboisière in Paris.

For heating purposes, hot water is usually employed at a temperature below 212° Fahr. The boiler is situated at the lowest point, and the outflow and return pipes are respectively connected with the top and bottom of the boiler;—the circulation depending upon the fact that the water in the pipe leading from the boiler is hotter, and therefore lighter, than it is in the return pipe. A feeding cistern and vents for the escape of steam must be provided at the highest points, and the system should be so planned that by means of valves and connecting pipes

the hot water may be turned off at given points to permit of "short-circuiting" when required.

In Perkins's system the hot water is under pressure at temperatures considerably exceeding 212° Fahr. Strong half-inch iron pipes are used, and a boiler is dispensed with,—part of the pipe being carried through the fire. Steam may be used at high or low pressure in a similar manner.

Another mode of ventilation by extraction, and one which is frequently used in prisons, consists in having a large foul-air extraction-shaft or shafts, heated by a furnace at the bottom, and into which foul-air flues, leading from all parts of the building, are conducted. The workmanship in this case requires to be very perfect, so as to prevent any large currents of air reaching the shaft except through the flues. The column of air in an extraction-shaft may also be heated by gas, or a steam jet may be used as the extractive force.

By a combination of these two methods—viz. heating the fresh air before entering by hot-water or steam pipes, and securing the removal of the vitiated air by flues leading to furnace-shafts or heated extraction-shafts—the largest buildings can be well warmed and ventilated. If necessary, the hot-water pipes may be made to pass through shallow basins of water, to ensure a sufficiency of moisture in the contained air.

Almost all large mines are ventilated on this principle of extraction. By means of a furnace at the bottom of the upshaft, the air is drawn down another shaft and made to traverse the various galleries by an arrangement of partitions and double doors. In well-ventilated mines as much as 2000 cubic feet of air per head per hour can be supplied in this way, and in fire-damp mines, 6000. In some mines the extractive force is exerted by means of a powerful rotatory exhaust fan

placed at the top of the upcast shaft, but whatever means may be used it is evident that an enormous volume of air must be passed through the various galleries per hour in order that the impurities of respiration from men and ponies, and products of combustion of lights and often of gunpowder blasting, may be removed and constantly replaced by fresh air. In coal-mining the injurious gases given off in gunpowder blasting need no longer be a source of danger to the health of the miner since the introduction of quicklime cartridges, which swell up when water is poured over them and exert their force without evolving any gas. Dynamite, too, is now largely used instead of gunpowder, on account of its greater explosive force, and it is preferable on health grounds because the gases evolved contain no carbonic oxide, which constitutes $7\frac{1}{2}$ per cent of the gases given off in gunpowder blasting.

In men-of-war and steam-vessels an iron casing surrounding the bottom of the funnel and upper part of the boilers is utilised as an extraction-shaft. When the fires are kept burning, so great is the current which rushes up this shaft, that the air can be drawn through the hatchways from all parts of the vessel, and even the hold and timbers ventilated.

In theatres, and other buildings of a similar description, the chandeliers should always be employed to extract the vitiated air. According to the experiments of General Morin, one cubic foot of gas can be utilised so as to cause the discharge of 1000 cubic feet of air. Apart, therefore, from the great advantages arising from the direct removal of the products of combustion, the aid to ventilation furnished by the extractive power of gas-lights merits special attention, for as a common gas-burner will burn nearly three feet of gas per hour, its extractive power could thus be utilised to remove nearly 3000 cubic feet of vitiated air during the same period. Where a large flood of light

is required, the "sun-burner" acts very efficiently in this way, and for smaller rooms or workshops, the "box-top sun-burner" is found to answer very well. The "ventilating globe-light" ought also to be mentioned amongst improvements in this direction. It is so arranged that so soon as the gas is lighted, an upward current is produced in the main tube, and as this becomes heated, the air in the surrounding tube near the ceiling becomes rarefied and set in motion. In this way the heated air in both tubes is carried to a special shaft or to the chimney, thereby securing the removal of the products of combustion and a steady current outwards of the vitiated air in the room. Tubes of tin or zinc placed over common burners, and communicating with the external air, or leading into the chimney, would answer the same purpose when ornamentation can be dispensed with; but in either case it is necessary that the room should be well ventilated, otherwise the extractive force of the fire will most likely occasion a down-draught through the ventilating tubes.

Extraction by means of a steam jet, and extraction by a fan or screw, are now generally abandoned on the large scale. What is known as the Archimedean-screw ventilator, however, has been lately recommended for small air-shafts, and has also been applied to large factories, where it may be worked by gas or steam power. In mines, the fan has been made to extract as much as 45,000 cubic feet of air per minute. Another fan known as the Blackman Air Propeller is very powerful in its action, and can be used either for exhaustion or propulsion. Such plans are especially applicable for the removal of dust in the textile trades, and in dry-grinding.

The system of ventilation by propulsion was first introduced by Dr. Desaguliers in 1734. It is carried on by means of a fan enclosed in a box, which can be worked by hand, horse, water, or steam, power. The air

enters through an opening in the centre of the box, and is thrown by the revolving fan into a conduit which communicates by proper channels with the different parts of the building. In France and America the fan is employed in the ventilation of several of the large hospitals, the air being forced into a basement chamber, where it is heated before it enters the wards. This is known as Van Hecke's system. The ventilation of the Houses of Parliament, Westminster, affords an example of a combined method of propulsion and extraction. By means of fans, air is propelled along conduits to the basement where it is warmed in winter by passing over steam pipes and cooled in summer by cold-water sprays or by passing over ice. From the basement it passes through shafts into the space beneath the grated floor of the House, which is covered with a peculiar open coating of whipcord permitting of free passage for the entering air. The vitiated air passes through a perforated glass ceiling in the roof, and is then conducted by a shaft to the basement of the clock tower, where it passes into the flue of a large furnace.

Amongst systems which owe their efficacy to the mechanical force of water may be mentioned the Eolus Spray Ventilator and Verity's system. In the former a fly-wheel fitted with fans is made to revolve by the jet of water directed against it, and in the latter, the air is set in motion by a spray of water from a number of fine jets. In both systems the rate of motion of the air can be regulated by the tap which supplies the water.

General Considerations.—With regard to the relative position of inlets and outlets, there seems to be some difference of opinion. Theoretically, the inlets for the fresh air should be situated near the floor, and the outlets near the ceiling; but the question of temperature interferes with the practical application of this rule. If the air is not warmed before entering, the inlets should be at

least nine or ten feet from the floor, or close to the ceiling, and so constructed that the cold air will impinge against the roof, and fall gently into the room. They should slope upwards to prevent entrance of rain, and should communicate with the external air by means of perforated bricks or gratings, so as to divide the entering current and break its force. With vertical tubes such as Tobin's or Shorland's tubes, the inlets need only reach about six feet from the floor. Sliding covers, valves, or rotatory discs might also be provided, in order that they may be partially or totally closed during rough weather. If the air is warmed before entering, the inlets may be situated, and generally are situated, near the level of the floor. But in either case it is essential that they should be equally distributed throughout the room, to ensure proper diffusion, and that the structural arrangements should permit of their being readily cleaned out, because dirt is sure to accumulate.

The outlets, as already stated, are best situated in or near the ceiling, not only because air vitiated by respiration tends to ascend on account of its lessened density, but because experiment proves that, given the same extractive power and the same size of outlet, a greater volume of air passes up a flue whose orifice is near the ceiling than up one whose orifice is near the floor. Inlets and outlets should not be situated near each other, otherwise the entering air will be extracted without being first diffused throughout the room.

Outlet tubes, or foul-air flues, as they are generally called, should be smooth, so as not to impede the current of air by friction, and they should be air-tight. When built in external walls and only plastered, I have frequently satisfied myself by experiment that the outside air finds its way into the flue, and sometimes in such volume that though there may be a good current issuing from the

top, scarcely any current can be detected entering it at the bottom. I have also found that when the wind beats strongly against the side of a building, with foul-air flues situated in the outer walls, a current of air may actually be issuing from both orifices at the same time. The experiments of Pettenkofer explain how readily such an occurrence may take place, for he has proved beyond doubt that even under ordinary atmospheric conditions, a very considerable interchange of gases takes place through common dry-plastered walls, and indeed, as the sick often experience, very perceptible draughts find their way through outer walls when a stiff breeze is blowing. All foul-air flues, therefore, should be as nearly air-tight as possible, and if they were made of metal tubing, or of glazed earthenware, they would not only satisfy this condition, but would serve greatly to lessen the friction, which is such an impediment to ready extraction through common plastered flues. It is further evident that, when it can be avoided, they should not be situated in external walls, because in cold weather the air becomes cooled as it ascends, and unless the extractive power is very considerable, the increased weight of the column of air by loss of heat will counteract the extractive force. Where there is no system of artificial extraction, it thus often happens that outlets become inlets, and inlets outlets.

Another very important point remains to be considered, namely, the sectional area of the inlets and outlets. As atmospheric conditions are constantly varying, it is obviously impossible to fix upon any size which will meet every requirement. The only alternative, therefore, is to provide an area that will suit the majority of cases, and which will be capable of being increased or diminished according to circumstances. Prof. Parkes has pointed out that in his country a size of 24 square inches for inlet

per head, and the same for outlet, is the one best adapted to meet common conditions.

In natural ventilation the volume of air passing through any flue may be calculated approximately by means of what is known as Montgolfier's formula, which is founded on the dynamical law that the velocity in feet per second of a falling body is equal to eight times the square root of the height through which it has fallen. In this instance the height fallen is represented by the difference of pressure between the inside and outside air, and this is based on the difference between the inside and outside temperature. Now, as the ratio of expansion of air for every degree Fahr. is ·002 or $\frac{1}{491}$ of its volume, the problem as suggested by De Chairmont may be expressed as follows:—

$$v = 8\sqrt{\frac{(h-h')\,(t-t')}{491}}$$

where v = velocity in feet per second.

h = height of exit aperture from ground.

h' = height of entrance aperture from ground.

t = temperature of inside air.

t' = temperature of outside air.

The velocity per second multiplied by the sectional area of the flue in feet, or decimals of a foot, will give the number of cubic feet of air ascending the flue per second. But a considerable allowance, varying according to circumstances from one-fourth to one-half, must be made for friction; while another element of error creeps in which cannot be estimated, inasmuch as the movement of air in all flues is greatly influenced by the varying force of the wind. The loss by friction in tubes or flues of similar size and sectional area will be directly as the length of tube or flue, and if they are dissimilar in size it will be inversely as the cross section of each. Then, again, the amount of loss by friction depends

greatly upon whether there are any bends in the tube or flue, and whether it is circular, inasmuch as a circle is the figure which includes the greatest area within the smallest periphery.

It may be said generally that though natural ventilation is less costly, it is inconveniently subject to atmospheric conditions, and is inadequate for the efficient ventilation of crowded buildings, such as schools, churches, theatres, and the like. The advantages of artificial ventilation, on the other hand, are its constancy under all conditions, and the facilities which it affords for regulating the volume of fresh air delivered, and for permitting facilities for its preparatory treatment as regards temperature, moisture, and purification. This was well illustrated in the valuable report submitted in 1889 by Professor Carnelly to the School Board of Dundee, as will be seen from the following table:—

Cubic Space per Person.	Naturally Ventilated.				Mechanically Ventilated.			
	No. of Cases.	Carbonic Acid.	Organic Matter.	Total Micro-Organisms.	No. of Cases.	Carbonic Acid.	Organic Matter.	Total Micro-Organisms.
Cubic feet—								
50–100 .	6	21·5	16·2	119	—	—	—	—
100–150 .	14	15·5	19·6	128	7	14·0	7·8	23
150–200 .	5	18·9	12·3	150	8	11·4	9·6	14
200–250 .	9	21·1	16·8	188	5	11·8	12·3	10
250–300 .	4	17·1	9·5	187	—	—	—	—
300 and upwards	4	15·1	11·8	12	6	13·0	3·7	2

He also estimated that the cost per head to ventilate a school to accommodate 1000 children, and also to warm it, may be put down at $2\frac{3}{4}$d., while on the artificial system it would amount to about $7\frac{1}{2}$d., representing a total difference of about £20—a very small expenditure to secure such highly desirable results. The plan of

ventilation which he recommended, after investigating several methods in use, was propulsion by means of a fan or fans, driven by a gas-engine, and he also recommended that the fresh air should be filtered through coarse jute cloth.

Schools of moderate dimensions are perhaps best warmed and ventilated by means of hot-water pipes, with the addition of ventilating grates when required. Small schools can be best warmed and ventilated by ventilating grates or stoves.

A few remarks may now be added with regard to lighting. Daylight illumination in respect to living rooms, workshops, factories, and schools is a matter of prime importance to health and comfort. In schools the area of the window-space should be not less than one-tenth and not more than one-fourth of the floor space. The schoolroom should preferably be of oblong shape, with the windows on one of the longer sides only, because cross-lights should always be avoided as far as possible. The desks should be at right angles with the windows, and so arranged that the scholars may sit with the windows on their left.

With regard to artificial lighting, it may be said generally, that the commonest method of illumination depends upon the combustion of inflammable vapours or hydro-carbons, whether derived from coal-gas, oils, or candles. In coal-gas illumination various kinds of burners have been devised to increase not only the luminosity but the steadiness of the flame. Many of the common kind of burners, such as the "fish-tail burner" or the "bat-wing burner" do not ensure complete combustion, and are apt to flare up when there is any increase of pressure. The improved "Argand burner," which is circular and must be enclosed in a glass chimney, gives a much steadier and softer light, and

ensures much more complete combustion. Other burners, as already pointed out, have been devised to assist very materially in ventilation, such as the "sun-light burner" and the "globe-light burner." What is known as Siemens's "regenerative gas burner" not only gives a brilliant light, but is so arranged with ventilating tube that the products of combustion can be conveyed into the outer air. It is well adapted for lighting large halls and public buildings, and for street lighting. The Welspach "incandescent gas burner" consists of a Bunsen burner with an asbestos gauge mantle treated with sulphate of zirconium. This mantle is suspended in the flame, and becoming incandescent yields a very bright light, and much whiter than the ordinary gas flame. Both flame and curtain must be enclosed in a glass chimney.

In order to equalise pressure throughout the gas-pipes in a house, what are called gas governors or regulators are employed and are placed near the meter. These are so constructed that when there is increased pressure, the lumen through which the gas passes is narrowed by the automatic action of valves, and when the pressure is diminished the lumen is widened. Single burners on the self-regulating principle have also been devised which answer very well.

Kerosene, the mineral oil commonly used for lamps, is distilled from crude petroleum. It gives off an inflammable vapour which ignites at varying temperatures, according to the quality of the oil. This temperature is called the flashing point, and by Act of Parliament it must not be lower than 100° Fahr., to prevent risks of explosion. Vegetable oils, such as colza oil, do not give off inflammable vapours, but they are much dearer than mineral oils, and their illuminating power is less. Candles, and especially the commoner

sorts, give off considerable quantities of unconsumed carbon.

Electric lighting is rapidly coming into use, and apart from its superior illuminating properties it possesses several sanitary advantages over other illuminants, inasmuch as there is no oxygen consumed, no products of combustion thrown off to pollute the air, and the heat produced is very trifling. Moreover, the light is not yellow, but white, and resembles solar light. For domestic lighting, incandescent lamps are the most suitable.

CHAPTER V

EXAMINATION OF AIR AND VENTILATION

A DETAILED examination of the sufficiency of ventilation in any particular case will embrace the following inquiries :—

1. The arrangements as regards space, the relative size of inlets and outlets, the distribution of the air, and the amount of fresh air supplied.
2. The examination of the contained air by the senses.
3. Chemical examination of the contained air.
4. Microscopical and bacteriological examination of suspended impurities.
5. Examination as regards temperature, moisture, etc.

SECTION I.—EXAMINATION AS REGARDS SPACE AND VENTILATING ARRANGEMENTS

To ascertain the exact size of a room, it is necessary first to calculate the floor space, and afterwards the cubic space. If a room is oblong, and has a flat ceiling, the only measurements required are the length of the room, the width, and the height. The width and length multiplied together will give the superficial area or floor space, and this multiplied by the height will give the cubic space. But it very often happens that rooms are of irregular shapes with the sides neither parallel nor at right angles to each other, or there may be projections or

recesses, angular or circular, while the ceiling may slope, either partly or altogether, or be dome-shaped. Or a room may be circular, such as a circular ward, or shaped like a truncated cone or pyramid, such as is sometimes found in the towers of modern built mansions and hotels. In mostly all these cases it will be necessary to divide the room into sections, and apply the rules for the measurement of these sections.

The more important of these rules may now be given, and first as regards area or superficies :—

Area of square	= Square of one of the sides.
Area of rectangle	= Multiply length by width.
Area of triangle	= Multiply base by one-half height, or height by one-half base.
Area of any figure bounded by straight lines	= Divide into triangles and take the sum of their areas.
Area of circle	= Multiply square of diameter (D^2) by ·7854, or square of circumference (C^2) by ·0796.
Circumference of circle . .	= $D \times 3{\cdot}1416$.
Area of an ellipse . . .	= Multiply the product of the two diameters by ·7854.
Area of segment of circle . .	= To two-thirds of the product of chord and height add the cube of the height divided by twice the chord $= \frac{2}{3}(Ch \times H) + \frac{H^3}{2Ch}$.

As regards cubic capacity, the following rules or examples may be given :—

Cubic capacity of a cube or solid rectangle	= Multiply together the length, width, and height.
Cubic capacity of a solid triangle .	= Multiply area of section (triangle) by depth.
Cubic capacity of a dome . .	= Multiply area of base by two-thirds height.
Cubic capacity of a cylinder .	= Multiply area of base (circle) by height.
Cubic capacity of a cone or pyramid	= Multiply area of base by one-third height.

In estimating the cubic capacity of a bell-tent, the capacity may be taken as that of a cone, or of a cone resting on a short cylinder. In estimating the cubic

capacity of a marquee, or of a circular building with dome, or of a room irregularly shaped, it will be necessary to divide into sections, and calculate the results of the various measurements separately.

After the cubic capacity of the room has been ascertained, corrections must be made for the larger pieces of furniture, bedding, etc., and for inequalities in the contour of the space. For instance, the displacement caused by solid projections into the room must be deducted, and the cubic contents of open recesses added. The allowance for each bedstead may be put down at 10 cubic feet, and for the space occupied by the body of each adult person at 3 cubic feet. After all these corrections have been made, it is of course an easy problem to ascertain the cubic space per head, though, so far as practical ventilation is concerned, any space higher than 14 feet ought not to be taken into account in respect to living rooms or dormitories, but all the measurements should be noted, and the total cubic capacity ascertained.

The next points to be inquired into are the relative position of inlets and outlets. Perforated bricks and gratings can be approximately estimated as regards their total open sectional area, by taking their actual superficial area, and calculating the relative size of the interstices. Inlets should be inspected as regards their freedom from accumulation of dust, etc., and outlets as regards the presence of any impediments to the ready exit of the vitiated air. Where there are open fire-places, the sectional area of the smoke flue must also be ascertained. The existence or otherwise of unpleasant draughts, and the relative position of doors and windows, and how far they assist in the ventilation of the room, are other items which must not escape notice. If the system of ventilation is artificial, it should be examined in all its details, and in this examination great assistance will be derived

from inspecting the architect's plans, whenever they can be procured.

The directions of air-currents in a room can be ascertained by means of the smoke from smouldering cotton velvet, fibres of floss-silk, small pieces of feather, small balloons filled with hydrogen gas, etc. The flame of a candle is often used for the same purpose, but it is of no value when the currents are delicate, because it is unaffected by them, but is of considerable service in showing whether air is entering or issuing through any opening. Very frequently, as has already been pointed out, openings that are meant to be inlets act as outlets, and *vice versa*, or the movement of air in them may be unstable, intermittent, and reversed in its action, now entering and now issuing through the same opening.

All these points, and others which may arise from peculiarities of structural arrangement, should be carefully inquired into, and the various measurements and observations noted down as they are made. When the ventilation is intended to be carried on independently of open doors and windows, these should be closed during the examination.

In determining the rate of movement through the various openings, an instrument called an anemometer is generally used. This may briefly be described as a miniature windmill. The little sails, driven by the air-current, set in motion a series of small cogged wheels, which move an index or indices on a dial-plate. The velocity of the current can thus be read off for a given time, in the same way as the amount of gas which has been consumed is ascertained from a gas-meter. A very beautiful and delicate instrument of this description has been constructed by Mr. Casella of Hatton Garden, with indices on the dial-plate indicating the velocity of an air-current in feet, hundreds of feet, thousands, etc., up to

millions. By moving a catch, the machinery may be stopped at any moment of time. With this instrument, the rate of movement of air through any opening is readily, and, as a rule, accurately ascertained. Before using it, the index indicating feet in units should be set at zero, and the relative position of as many of the other indices as may be deemed necessary noted down. When the instrument is placed in the air-current, time is called, and the catch moved to set the machinery free. At the end of one minute, two minutes, etc., according to the length of period of observation, time is again called, and the machinery immediately stopped by means of the catch. The linear dimension of the current is then read off, and if this is multiplied by the sectional area of the opening, the volume of air which has passed through in a given time can be easily calculated in cubic feet. When the instrument is placed in a tube or shaft, it should be put well in, but not quite in the centre, because the velocity of the current in the centre is greater than at the sides of the tube. Should the shaft be large, the rate of movement ought to be taken at different parts, and the average ascertained. So also, when the rate of movement is irregular, several observations should be made, and the average of the whole of them will give the approximate velocity of the current. If placed in a tube whose sectional area exceeds but very little the space occupied by the revolving sails, the results cannot be depended on; and when placed at the entrance of a tube, as for example, against a perforated air-brick or grating, the velocity of the current indicated by the anemometer is considerably less than what exists in the tube. In these cases the instrument should be exactly fitted into an opening in a box, large enough to cover completely the mouth of the tube, by which means the whole of the air passing through the tube may be made to pass through the opening in the box.

The amount of air found to be issuing up chimneys or other outlets is a far more reliable index of the fresh-air supply than the amount actually ascertained to be entering through the inlets; and indeed the fresh-air supply can only be fairly estimated in this way. As already stated, the air enters through every chink and cranny, and in dry plastered walls may enter, to no slight extent, through the walls themselves. Hence the difference between the amount of air found to be entering through the regular fresh-air inlets and that found to be issuing through the outlets is often very great. In a ward containing 15 beds, with one door, eight windows, and four inlets for fresh air, I have found that while only 880 cubic feet of fresh air were entering through the inlets per bed per hour, as much as 3150 were found to be issuing up the two chimneys and the three extraction-flues of the ward. During the experiments the door and windows were shut, and brisk fires kept burning in the two ventilating fire-places. The large amount, therefore, of 2270 cubic feet per bed per hour entered through chinks in the window-frames, and beneath and around the closed door. Very probably, in this instance, a considerable amount was also drawn, by the extractive force of the chimneys and flues, through the walls, inasmuch as they were built of brick, and were only whitewashed and not plastered.

When an examination of the respired air itself is intended, a suitable time must be selected during which all the conditions of the efficiency of the ventilation, in any given instance, can be fairly put to the test. Take a hospital ward, for example. It is necessary that all the beds should be occupied, that windows and doors be kept shut, if ventilation is intended to be effectually carried on without them, and that an hour should be selected in the night-time when the greatest accumula-

tion of impurities is likely to occur. Any hour between midnight and 5 A.M. would meet this condition in most cases. In order to make the examination as complete in detail as possible, it is necessary to have a wet and dry bulb thermometer placed outside some time previously, and several others fixed at different positions in the ward. The outside and inside temperature can thus be compared, and the relative hygrometricity of the air indoors and outdoors ascertained. If the barometer is read off at the same time, and the state of the weather recorded, all the meteorological data are obtained which are usually considered necessary for a full and exhaustive report.

SECTION II. THE EXAMINATION OF THE CONTAINED AIR BY THE SENSES

With a little practice, this method of examination gives tolerably reliable results; but it is necessary that one should remain for some short time in the open air, before entering the ward or room to be examined, otherwise the sense of smell is likely to be blunted and unable to appreciate the degree of closeness or foulness. One of the terms "not close," "rather close," "close," "very close," "foul," "very foul and offensive," will indicate, with sufficient accuracy, the degree of perceptible impurity in the majority of cases. The following selections from Dr. de Chaumont's experiments show how closely the sensations accord with the different degrees of impurity indicated by the percentage of carbonic acid:—

At ·1408	per cent.	Extremely close and unpleasant.	At ·0843	per cent.	Not very foul.
,, ·1090	,,	Extremely close.	,, ·0804	,,	Close.
,, ·0962	,,	Very close.	,, ·0658	,,	Not very close.
,, ·0921	,,	Close.	,, ·0568	,,	Not close.

SECTION III.—CHEMICAL EXAMINATION

1. *Carbonic Acid.*—In the chemical examination of respired air, the chief point to be determined is the amount of CO_2 per 1000 volumes. Pettenkofer's method is the one most generally adopted, because it is fairly accurate and easy of application. The apparatus required for the latest modification of his process are as follows:—

(1.) Wide-mouthed jar or bottle of a capacity of 4 to 5 litres fitted with india-rubber cap.

(2.) Pair of bellows with attached tubing.

(3.) Pipettes to measure 100 c.c. and 25 c.c.

(4.) One 4 oz. stoppered bottle and glass funnel, and four 100 c.c. flasks or beakers.

(5.) Small bottle of phenol-phthalein solution.

(6.) A solution of oxalic acid, 1·41 grammes to 1 litre of distilled water. Each 4 c.c. of this solution =1 c.c. of CO_2 at 0° centigrade and 760 m.m. pressure.

(7.) A solution of baryta, 2·8 grammes to the litre. This solution may be stored in a bottle, stoppered by a double perforated cork, the one opening carrying a short tube loosely fitted with pumice-stone moistened with potash, and the other a long tube bent syphon-wise, the shorter arm reaching to near the bottom of the bottle, and the longer fitted with a short piece of india-rubber tubing with clip. The baryta water can thus always be syphoned off clear, and as the air drawn in to replace the liquid drawn off is deprived of its CO_2 by the potash, the alkalinity of the solution will not become changed.

The various steps of the process are as follows:—

(*a.*) Take temperature of air and barometric pressure.

(*b.*) After taking care that the jar is dry and clean, pump the air of the room which is to be examined repeatedly into the jar, then pour in 100 c.c. of the baryta

solution, cover with cap, and shake vigorously for several minutes.

(*c*.) Pour the contents into the 4 oz. stoppered bottle and let it stand for some time.

(*d*.) By means of a pipette draw off two or three 25 c.c. portions and pour into the separate 100 c.c. flasks.

(*e*.) Add a few drops of phenol-phthalein solution to each flask, which will produce a beautiful pink colour, then drop in the oxalic acid solution from a burette, until the pink colour disappears, noting the number of c.c. required to effect this for each flask, and take the mean of the number of c.c. required for each portion as the correct number.

If the causticity of the baryta water has not been previously ascertained, take 25 c.c. and find the number of c.c. of the oxalic solution required to neutralise this quantity, the point of neutralisation being indicated by the disappearance of the pink phenol-phthalein colour. The difference between this number and the mean required for the neutralisation of the separate portions of baryta water shaken up with the air to be examined, will represent the amount of CO_2 which has combined with the baryta water to form carbonate of baryta.

For example, suppose the causticity of the baryta water is 18 c.c., *i.e.* that 18 c.c. of oxalic acid solution are required to neutralise 25 c.c. of the baryta water; and suppose further that the mean amount required for the neutralisation of the baryta water treated with the air in the jar is 16·5 c.c., then the difference 1·5 represents the number of c.c. of CO_2 contained in the whole jar of air, inasmuch as 4 c.c. of the oxalic solution $=1$ c.c. of CO_2, and the total quantity of oxalic acid solution required to indicate the difference of neutralisation was 1·5 for 25 c.c., or 6 for the whole quantity of baryta water in the jar, and $\frac{6}{4}=1{\cdot}5$ c.c. of CO_2.

In calculating the amount of CO_2 contained in the air, it is first necessary to deduct 100 c.c. for the quantity of baryta solution poured into the jar, and which therefore displaced so much air, and next we must find the volume which the air would occupy at 0° centigrade and 760 m.m. pressure. Thus, suppose the capacity of the jar is 4090 c.c., the temperature of the air 15·5° centigrade, and the barometer stands at 29·755 inches, the several steps of the calculation would be as follows:—

4090 c.c. − 100 c.c. = 3990 c.c. = the amount of air in the jar.

30 : 29·755 : : 3990 : 3957 c.c. = the correction for barometric pressure.

$\frac{3957 \times 273}{273 + 15 \cdot 5} = 3744$ = the correction for temperature, inasmuch as air increases in volume $\frac{1}{273}$ for each degree centigrade, or $\frac{1}{491}$ for each degree Fahr.

Then 3744 : 1000 : : 1·5 : 0·400 = the quantity of CO_2 present in the air examined per 1000 volumes.

Lime water may be used instead of baryta water, but it is not so soluble, and the experiment takes much longer time.

Amongst other methods of estimating the amount of CO_2 in air may be mentioned the method proposed by Mr. Wanklyn. The apparatus required are one or more large clean stoppered bottles, such as Winchester quarts, whose capacity must be carefully measured; a pair of bellows; several glass cylinders resembling those used for "Nesslerising"; a burette graduated into $\frac{1}{10}$ c.c. with stop-cock; a solution of dried carbonate of soda, 4·74 grammes to the litre of distilled water, 1 c.c. of which is equal to 1 c.c. of CO_2, or 1·97 grammes by weight; and baryta of a strength of 0·1 per cent. After pumping in the air of the place to be examined into the bottle, 100 c.c. of baryta are introduced, the stopper inserted, and

the bottle well shaken for several minutes. The baryta water, which is thus rendered more or less turbid according to the amount of CO_2 contained in the air, is then poured into a glass cylinder, and placed side by side with another glass cylinder containing 100 c.c. of clear baryta water. Into this latter the test solution of sodic carbonate is dropped from the burette until the turbidity of baryta water in the two cylinders is exactly alike. The amount of the test solution required to produce this turbidity is then read off, and as the capacity of the jar is known it is easy to calculate approximately the amount of CO_2 in the contained air. Thus, if the bottle contain 2000 c.c. of air, and the turbidity is imitated by using 1·8 c.c. of the test solution, the amount of CO_2 present would be 0·09 per cent., or 0·9 per 1000 volumes.

The method of Lunge and Zeckendorf requires a solution of carbonate of soda 53 grammes to the litre, coloured crimson, with ·02 gramme of phenol-phthalein. 10 c.c. of this solution are placed in a flask so arranged that the air, which is pumped in by an india-rubber pump of 70 c.c. capacity, is made to pass through the solution. The air is slowly pumped through until decoloration is complete, and the number of fillings or pump-fulls noted. This minimetric apparatus has been standardised by the Pettenkofer process, and a table prepared in which the number of fillings of the pump required to decolorise the solution represents a certain percentage of CO_2 in the air to be examined.

2. *Carbonic Oxide* (CO).—Unfortunately there is no very convenient test for the presence of this gas. It may, however, be determined quantitatively by exposing a measured volume of air to a solution of cuprous chloride in strong hydrochloric acid, which absorbs the gas, and the loss in volume would indicate the amount of CO present.

3. *Sulphuretted Hydrogen* may be detected in small

quantities either by exposing pieces of paper soaked in lead acetate to the air, or by passing air through a solution of this salt, when a dark or black colour is produced.

4. *Ozone.*—The various tests which have been recommended for detecting or estimating the presence of ozone are all more or less imperfect. Perhaps the most reliable test is to expose strips of iodised litmus paper to the air, when the greater or less conversion of the red litmus into blue shows a greater or less quantity of ozone present. Scales have been prepared for estimating the amount of ozone as indicated by the depth of colour.

5. *Organic Matter.*—The best method of estimating organic matter in the air is to draw a known volume of air through a little distilled water by means of an aspirator, and then estimate the quantity absorbed by the amount of oxygen consumed as determined by the Forschammer process (see Chapter on Water Analysis).

6. *Ammonia* is also collected by aspirating a known volume of air through distilled water, and then determining the amount quantitatively as in ordinary water analysis.

Section IV.—Microscopical and Bacteriological Examinations

The best method of collecting dust or suspended impurities for examination is to use a large aspirator of known capacity and draw the air through a tube at least one inch in diameter packed for two inches of its length with crystals of sugar or sodic sulphate. At the conclusion of the experiment this soluble filter is dissolved in distilled water, filtered through a small weighed filter, the filter washed, dried, weighed, and the weight noted as so much per cubic foot. This will indicate the amount of dust present, and the dust thus collected may be examined microscopically. In the same way if the water used for

dissolving the filter has been carefully sterilised by boiling the bacteriological indications of the impurities may be ascertained by cultivating in prepared nutrient media.

For the mere qualitative examination of dust, the air may be drawn through distilled water, or Pouchet's aeroscope may be used. This consists of a funnel-shaped tube ending in a fine point, beneath which is placed a slip of glass moistened with glycerine, on which the suspended matters are collected. Or Hesse's method may be followed. In this the air is drawn through a tube containing nutrient gelatine which has been previously sterilised, and on this medium moulds, fungi, and micro-organisms can be cultivated and examined.

Section V.—Examination as regards Temperature and Moisture

1. *Temperature.*—The various points connected with the temperature of the contained air, such as its equability, sufficiency, etc., are readily ascertained by a judicious distribution of thermometers throughout the space to be examined, and by comparing the outside with the inside temperature. The efficiency of the heating apparatus is of course best tested during very cold weather and in the night-time. When open fire-places are used the temperature should be noted at the remote parts of the room, and if the air is heated before entering, it is advisable to take the temperature at the point of delivery, and to ascertain whether it is well diffused or not.

2. *Moisture.*—The amount of watery vapour, or the hygrometricity of the contained air, may be determined by hygrometers such as Daniell's and Regnault's, or by wet and dry bulb thermometers. The latter are the most convenient and reliable, but they should be distributed some two or three hours before the observations are made.

Unless the air is saturated with moisture, the temperature of the wet bulb is always below the temperature of the dry, and the number of degrees of difference between them varies according to the amount of watery vapour present. This is generally represented in relative terms. For example, the point of complete saturation being assumed to be 100, any degree of dryness may be stated as a percentage of this, and can be conveniently ascertained by reference to Mr. Glaisher's tables.

The relative humidity of the air out of doors should also be ascertained at the same time, by way of comparison.

In carrying out experiments in ventilation, the hair-hygrometer gives sufficiently accurate results, and possesses a considerable advantage over the dry and wet bulb thermometer in rapidity of indication (see next Chapter).

In a room well ventilated and warmed the humidity ought to range between 73 and 75 per cent., the temperature should not fall below 60° Fahr., and the carbonic acid, as previously stated, should not exceed 0·6 per 1000 volumes.

In the examination of the air contained in the crowded dwellings of the poorer classes, the senses will alone sufficiently indicate the degree of impurity, but in all cases the cubic space per head, and the means of ventilation, should be carefully noted, because otherwise any suggestions as regards improvements will at the best be haphazard, and possibly ill advised.

CHAPTER VI

CLIMATE AND METEOROLOGY IN THEIR RELATIONS TO PUBLIC HEALTH

SECTION I.—CLIMATIC AND METEOROLOGICAL CONDITIONS

THE term climate may be defined as the combined effect of the atmospheric and telluric conditions which determine the suitability of various localities for the maintenance of animal and vegetable life. Apart from the chemical composition of the atmosphere, the most important factors of climate are the temperature of the air, its density, its humidity, its circulation as represented by winds, the amount of light which it distributes, and its electrical conditions. So far as the climate of any particular locality is concerned, these factors are determined by the distance of the locality from the equator; its elevation above sea level; its relative position to seas, inland lakes, deserts, flat plains, or mountainous regions; and its geological and topographical features generally. In addition to these there are many other modifying influences which go to form what are called local climates, such as the cultivation of the land, drainage of the subsoil, the planting of trees, the clearing of forests, the crowding together of dwellings, and the establishment of manufactories.

Various classifications of climate have been attempted by different writers, but all of them are more or less

arbitrary and necessarily imperfect. As temperature, however, is beyond all doubt the most important factor in the determination of climate, most classifications have been based on this consideration, and the simplest, perhaps, is that which recognises three principal kinds of climate, namely, warm climates, extending from the equator to 35° lat.; temperate climates, extending from 35° to 55° lat.; and cold climates, extending from 55° to the poles. These again may be subdivided into equatorial, tropical, sub-tropical, sub-polar, and polar; while, according to geographico-physical conditions, they may also be divided into insular and maritime, and inland or continental climates.

In considering climatic conditions it will be convenient to refer briefly to the physical features of the atmosphere on which they principally depend.

1. *Temperature.*—As solar heat is the source of all energy, so it exercises supreme control over climatic conditions. What is called radiant heat, or the heat radiated from the sun, although it possesses great power of warming solid and fluid bodies on which it falls, has little power of heating the air through which it passes. Indeed, were it not for the watery vapour contained in the atmosphere, pure air would be diathermic or transcalent;—in other words, radiant heat would pass through it without raising the temperature. It is the shade heat, or the heat reflected from the surface of the earth, whether land or water, and directly warmed by the radiant heat emanating from the sun, which regulates the temperature of the air. This shade heat, however, is greatly modified by winds, by the relative extent of land and water, by mountains, and by topographical conditions generally. Winds, for example, convey over immense distances the temperature of the regions from whence they arise, while owing to the greater specific

heat of water, which is as 4 to 1 compared with that of land, water takes longer to warm as well as to cool. Hence the sea, remaining open, excepting in the polar regions, is constantly modifying the strata of air coming in contact with it, and thus moderates the heat in summer and the cold in winter. It is on account of this specific heat of water that insular climates are more equable than continental,—the summers cooler and the winters warmer.

The effect of elevation in lowering temperature depends upon the fact that as heat is very slowly communicated from stratum to stratum of the air, and as the air is warmed chiefly by the surface of the earth, the lowest layers are the warmest, and the temperature on mountain tops is therefore much lower than on the plains below. This difference, however, is far more marked in the daytime than at night, and in summer than in winter. In fact, during severe frosts the conditions are generally reversed, and the temperature rises with height instead of becoming lower, so that a thaw may often be seen setting in on the hills while the frost is unbroken in the valleys below. If the air were perfectly dry, the rate at which the temperature would fall would be 1° Fahr. for every 180 feet ascent; but as the atmosphere contains moisture which is liable to be condensed by cold, the latent heat given out in condensation diminishes the rate of cooling, so that the rate of lowered temperature as a general rule may be taken at 1° Fahr. for every 300 feet in altitude. Indeed, apart from elevation, the chief effect of mountain ranges is to deprive the winds passing over them of the watery vapour which they convey. Hence the leeward sides of mountain ranges have colder winters and warmer summers, because the screen of vapour which would otherwise protect them from excessive heat or excessive radiation is removed.

The greater rainfall of our own western, and the greater dryness of our eastern shores, is due to a similar agency.

2. *Atmospheric Pressure.*—The weight of the air at the earth's surface is equal to a pressure of about 15 lbs. on every square inch of surface. If the density of the atmosphere were uniform throughout, its height would not exceed a limit of five miles; but as air is elastic and does possess weight, it is evident that the layers beneath must be more compressed than the layers above, and that the greater the height the lighter and more rarefied must these layers become, so that the limit of the atmosphere has been variously estimated to extend to a height of from 50 to 200 miles. The indications of the mercurial barometer merely represent the fact discovered by Torricelli in 1643, that a column of mercury of about 30 inches in height balances a column of air of the same thickness but extending to the height of the atmosphere. As the pressure of the atmosphere varies from day to day and even from hour to hour, the height of the mercurial column is subject to corresponding fluctuations. Indeed, the great use of the barometer is to indicate these changes of pressure, which are of special importance to the meteorologist, because they point to changes in the winds; and these are the prime agents in effecting changes in the weather.

3. *Movement of Air and Winds.*—As has already been pointed out, one of the effects of the warm sunbeams falling on land and sea, and of the heat radiated from them, is to warm the layers of air which successively come in contact with the surface; and as they are thus rendered lighter they ascend, and thereby produce upward currents. From the latitudes round the equator, these heated currents of air, after ascending and during their ascent, flow northwards and southwards to the polar regions. During their course they become colder and condensed, and therefore

sink towards the earth, again returning towards the equator to complete their round of action. But all the while the earth's surface is revolving from west to east at a rate of 1000 miles an hour at the equator, and at a lower rate of rotation according to latitude, until at the poles the velocity is reduced to zero, because the poles simply represent the ends of the axis on which the earth rotates. Moreover, as the atmosphere may be regarded as a gaseous shell which completely encases the globe, it necessarily shares in all its movements, and therefore moves round at the same rate as the surface on which it rests, and therefore the atmosphere, while quiescent over the poles, moves with increased rapidity in lower latitudes, until at the equator it attains a speed of 1000 miles an hour. Hence the currents of air which, as we have seen, are continually flowing from either pole in a direct north and south line will constantly tend to lag behind the surface of the earth as they move towards the equator. Thus the current starting from the north pole, as it passes south, acquires a relative motion from east to west, and as a resultant of the two motions, that from the north with that from the east, the wind thus produced would seem to come from the north-east; in other words, it would appear as a north-easterly and not as a northern wind. In this way it comes about that winds, more or less constant in direction, blow across those parts of the Atlantic and Pacific Oceans which lie for some distance on the two sides of the equator; the direction being from the north-east in the northern tropics, and from the south-east in the southern tropics. These winds, which were of so much importance to navigation before the days of steam-ships, were therefore called the *trade* winds. Athough these winds are more or less constant, they are greatly modified by local circumstances, such as the distribution of land and water, the character of the sea-

shore, and the altitude of the more inland regions. They are not equally marked in the two great oceans, nor are they equally strong at all seasons.

On the other hand, it will be readily understood that the air which rises from the heated equatorial belt, on reaching the higher regions of the atmosphere, flows northwards and southwards towards the polar regions over the currents which are sweeping across the surface below. But these upper currents are blowing from regions of high velocity to regions of lower velocity of rotation, and consequently they move more rapidly in the direction of the earth's rotation than the surface immediately beneath them. Hence they are deflected from a simple north and south course, but in an opposite direction to that of the trade winds, so that in the northern hemisphere they become south-westerly winds and in the southern hemisphere they blow from the north-west. Such upper currents, moving in an opposite direction to the surface winds, may be recognised by their effects on high clouds. In the higher regions of the atmosphere they become chilled, and at about the thirty-fifth degree of latitude they become sufficiently condensed to descend to the surface. Part of the air then returns as an undercurrent to the equatorial belt, where it again ascends to complete its circulation in this region of the atmosphere, while another part of the descending air continues its course as a south-west wind in the northern hemisphere, and as a north-east wind in the southern hemisphere, but these winds are not so constant as the trade winds. The prevalent south-west winds of this country partake partly of this origin, and as they are laden with moisture they are the chief rain-bearers of the British Isles.

But the diurnal rotation of the earth exercises other effects on the circulation of the air, and as a notable instance what is known as the land-and-sea breeze may briefly be

noticed. As the sun's heat warms the surface of the land more rapidly than the surface of water, the layers of air which come in contact with it are more quickly heated, and therefore ascend, and are replaced by the colder currents flowing inward from the sea. During the night, however, the current is reversed, for while the surface of the sea remains at pretty much the same temperature as during the day, the surface of the land radiates or gives off heat more rapidly and becomes cooled, and hence the breeze blows seaward. As regards other winds, however much they may vary in force or direction, they are all originated in the first instance by solar heat,—their variety being accounted for by the rapidity of the motion of the earth's surface at various latitudes, by differences of temperature, by unequal distribution of land and water, and by local peculiarities, such as mountains, valleys, or far-reaching level plains.

4. *Humidity.*—Another most important function which the atmosphere discharges in relation to life and health is to act as nature's water-carrier; and here again the sun is the active agent, for the action of solar heat upon water is to convert it into vapour. Hence over the vast surfaces, more especially of equatorial seas, a process of distillation is incessantly going on;—the watery vapour laden with the heat absorbed in its production is carried up by the air currents just described, and may thus be wafted thousands of miles before it becomes condensed and falls to the earth. Indeed, we in this country are chiefly supplied with water distilled from the seas which lie between the tropics, and, moreover, we owe in great measure the mildness of our climate to the latent heat conveyed by this watery vapour, and which is again set free when it becomes condensed to fall to the earth as rain or snow.

It need hardly be said that the amount of watery

vapour present in the air is constantly varying, and the amount varies according to the temperature. Indeed, the higher the temperature the greater the quantity of water which may exist in the state of vapour; in other words, the capacity of air for containing watery vapour increases in direct proportion to its temperature.

The quantity of vapour contained in a given amount of air is called the *absolute humidity,* while the proportion of vapour actually present in the air to the amount which it would contain when fully saturated is called the *relative humidity.* When we speak of dry air, and humid or moist air, it is meant that the relative humidity is low or high. The degree of the former varies with the seasons, being higher in summer than in winter; whereas the latter generally follows an opposite course, being lowest mostly in May and June, and highest in December and January. When, therefore, the temperature of the air becomes lowered, the relative humidity rises, and if this continues up to saturation, condensation of vapour occurs, which on solid bodies shows itself as dew, or in the air itself as mists or clouds. When further condensation takes place under the influence of still lower temperature or increased barometric pressure, the clouds are transformed into rain or snow.

The conditions on which the amount of rain depends are partly general, such as degree of latitude and elevation above sea level; and partly local, as nearness of large surfaces of water, exposure to moist winds, or proximity to mountain ranges. As a rule, the amount of rainfall decreases with increasing distance from the equator, but this rule has many exceptions. Moreover, the amount of rainfall in different regions is not proportionate to the humidity of the air, inasmuch as a region may almost be rainless in spite of a humid atmosphere, if there are no cold winds to produce condensation; while, on the other

hand, localities with considerable rainfall may enjoy tolerable dryness of air and subsoil. The capacity of the air of any locality to take up moisture depends on the temperature, the relative humidity, the density, and the rapidity of air movement. It is increased by rise of temperature, dryness of the air, and by wind, while it is diminished by lowering of the temperature, absence of sun, stillness of the air, and high degrees of relative humidity.

Atmospheric moisture is the great regulator of the distribution of the heat over the surface of the earth. While it moderates in some degree the direct solar rays of heat and light, it acts still more powerfully by absorbing the radiant heat reflected from the surface; indeed, were it not for the watery vapour present in the air, the whole surface of the earth would become frozen in a single night. Even the dew, which is formed by nocturnal refrigeration, becomes an additional protection in preventing the earth's heat from radiating into space.

What is called the *dew-point* is the temperature at which the air is so completely saturated with moisture that the least further fall causes condensation. If the dew-point be below the freezing-point, the moisture deposited will pass at once into the solid form and appear as hoar-frost. This, however, is not frozen dew, but moisture deposited in the solid form. Clouds, by reflecting back the heat radiated from the earth, prevent the deposition of dew, nor can dew be deposited when there is much wind, because the air cannot remain long enough in contact with the surface for any material reduction of temperature and consequent condensation to take place.

Clouds are formed by the condensation of vapour in a stratum of air at a considerable height, and are constantly disappearing to be reformed. The warm air charged with moisture rises, is condensed, forms a cloud, and

begins to fall, but coming in contact with another warm layer of air, the moisture which it contains is vaporised to a certain extent and the cloud changes in form or disappears. The curious phenomenon of a cloud clinging to the side of a mountain when a strong wind is blowing is explained by the fact that it is as quickly formed as it is blown away. A mist is merely a cloud near the surface of the ground, and is distinguished from a fog by the particles of moisture being somewhat larger. Fogs are generally caused by the intermixture of masses of air of varying temperatures, by warm currents of moist air flowing over cold surfaces, or by cold air flowing down into a warm and damp atmosphere. The condensed moisture constituting a fog has a tendency to deposit itself on foreign particles floating in the air, and accordingly London fogs are pre-eminently opaque owing to the enormous amount of carbon, in the form of soot, which the atmosphere holds in suspension.

5. *Light and Electricity.*—The relations of these two factors in their effects on climate are so closely allied with conditions of temperature that they do not admit of strict differentiation. There is no doubt, however, that they both exercise important influences on organic function, and are intimately connected with what are known as bracing or relaxing conditions. The observations made at the Kew observatory tend to show that the atmosphere always contains free electricity, which is positive in far the greater majority of instances at about 5 feet above the surface of the ground, but is generally negative close to the surface. Although both positive and negative electricity can be detected in the air of dwellings, the former is soon used up if efficient ventilation is impeded.

Section II.—Meteorological Observations

The principal meteorological observations which are systematically recorded at numerous stations throughout the country include atmospheric pressure, temperature, humidity, rainfall, force and direction of winds, and the indications presented by clouds.

1. *Atmospheric Pressure.*—Although there is a great variety of barometers designed for common use, the instrument as usually constructed for scientific observation purposes consists of a glass tube about 34 inches in length, closed at one end, filled with mercury, and placed vertically with the open end dipping into a cup containing mercury. This type of barometer is known as the *cistern* barometer. Another type, namely, the *syphon* barometer, consists of a tube bent in the form of a syphon, having the same diameter at the lower as at the upper end, and though in many respects it is a more perfect instrument than the cistern barometer, it presents the great disadvantage of necessitating two readings, one for each arm of the syphon. A modification of the syphon barometer, familiar in many houses, is known as the *wheel* barometer, but this has little to recommend it as a trustworthy instrument. The *aneroid* barometer, on the other hand, is simply an air-tight circular metallic box from which the air has been nearly exhausted. The elastic sides of the box, which are kept apart by a delicate spring, are acted upon by the varying pressure of the atmosphere, and the resulting movements are conveyed by levers to an index which moves on a circular graduated scale.

What is called the standard land barometer, known as Fortin's *cistern* barometer, is the instrument recommended for accurate scientific observations. The special feature of this instrument consists in a pliable leather base to the cistern, which can be lowered or raised by

means of an adjusting screw, so that the surface of the mercury in the cistern can always be accurately adjusted to the same level, or what is called zero-point, when the readings are taken. A small ivory pin, the point of which represents the zero-point of the tube, is fixed to the upper frame of the cistern, and when an observation is taken, the surface of the mercury is made to coincide with the point of the pin as the standard level from which the barometric column is to be measured. The cistern, or upper part of it, is made of glass, in order that the ivory pin and the surface of the mercury may be visible, and the tube itself is enclosed in a brass case, on the upper part of which the scale is measured. Unless the instrument is required for use at great heights, the scale is only divided on the parts usually required, viz. from 27 to 32 inches, and each inch is divided into tenths and half-tenths, or 0·100 and 0·050 of an inch.

In order to increase the accuracy of the readings, there is attached to the scale of every standard barometer a small movable scale, worked by a rack and pinion, called a "Vernier," from the name of its inventor. This is divided into twenty-five spaces which correspond with twenty-four spaces on the fixed scale, and as each space on the fixed scale is 0·05 inch, it is larger than a space on the vernier by the twenty-fifth part of 0·05 inch, or 0·002 inch, so that the vernier shows differences of two-thousandths of an inch.

Another necessary adjunct of the instrument is the attached thermometer, the bulb of which should either be close to the tube or should enter the cistern. Great care should be taken with respect to the position of the instrument. It should always be fixed in a good light, but out of the reach of sunshine, and as far as possible from the direct heat of a fire or lamp. It should hang absolutely vertically, and at such a height that the eye

of the observer should be as near as possible on a level with the top of the mercury.

In making an observation there are three points which should be remembered, and they should be attended to in the order in which they are mentioned. First take the reading of the attached thermometer; next adjust the mercury in the cistern by means of the thumb-screw, so that it exactly touches the point of the ivory pin, which, with its reflection on the surface of the mercury, will then appear as a double cone; and lastly, adjust the vernier so that its lower horizontal edge forms a tangent to the convex curve of the top of the mercurial column. The exact height of the column is then read as follows:—

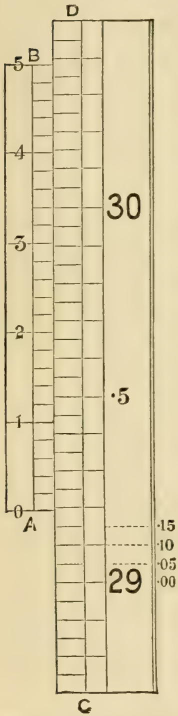


Fig. 6.—A B, Vernier; C D, part of fixed scale of Barometer.

Suppose after adjustment that the zero or lower edge of the vernier and the scale occupy the relative positions illustrated in Fig. 6, then it is seen first that the zero of the vernier is on a level with the part of the scale between 29·15 and 29·2 inches, so 29·15 is noted as the first part of the reading. On examining the subdivisions of tenths on the scale and on the vernier, it is next seen that the line on the vernier which forms a straight line with a line on the scale is the second line above 3, namely ·034, and this when added to the scale reading makes 29·15 + ·034, or 29·184 inches, which is called the observed reading.

For scientific purposes of comparison it is necessary that certain corrections should be applied to all barometric readings in order to bring the indications of different

instruments in harmony with each other, namely, those for index error, capacity, and capillarity furnished by the certificate of the Kew observatory which accompanies every good instrument; the correction for height above mean sea level; and the correction for temperature. Tables are given in Scott's *Instructions* and other publications, by the help of which the corrections for temperature and altitude can readily be made, and the following example from Scott's *Instructions* will show how these corrections are applied:—

Suppose that—

Barometer reading .	= 29·946 ins.
Attached thermometer	68°
Kew correction for instrument	= + ·014 in.
Temperature of air by dry bulb	= 50°
Altitude of cistern above the mean sea level	= 105 ft.

Then we have—

Uncorrected reading .	= 29·946 ins.
Add for Kew correction	+ ·014
Reading . . .	29·960
Deduct temp. correction for 68° and 30·0 ins.	− ·106
Reading at 32° F. .	= 29·854
Add for altitude of 105 ft. at temp. of air 50° and *approximate* pressure at sea level 30·0 ins.	+ ·116
Reading corrected and reduced to 32° F. at mean sea level	= 29·970 ins.

What are called *isobars* are lines, sketched on a map or chart, connecting all those places which have at a given time the same barometric pressure. Between two successive isobars the difference of pressure is represented by one-tenth of an inch of mercury, which is called the unit of pressure, and the distance between these two lines gives the *gradient*, the unit being one degree or 60 nautical miles. Hence a gradient of 4 means that over a distance of 60 nautical miles the barometer rises $\frac{4}{100}$ or ·04 of an inch. If the isobars run close together it shows that

the gradient is high, and therefore the winds will be strong; if they are wide apart the gradient is low, and the winds will be light. The former represents what are called *cyclones* or depressions; the latter *anti-cyclones.*

Generally speaking, it is not the actual height of the barometer at any given place and time, but this height as compared with surrounding regions, which indicates the coming weather. As a rule, a falling barometer indicates rain, and a rising barometer fair weather. A sudden fall usually foretells a storm, the severity of which is in proportion to the barometric gradient. A steady barometer indicates a continuance of the weather at the time; if high, it is generally fair; but if low, it is generally broken and bad. The variations must also be considered in relation to the prevailing winds. Thus in Great Britain a high and rising barometer frequently accompanies east winds with a drenching drizzle.

Although much may be learnt about winds by studying isobaric lines, it must not be supposed that the air blows directly from regions of high pressure to those of low pressure, but rather in a spiral course. The exact relation of winds to pressure is, however, generally indicated by the law laid down by Professor Buys Ballot of Utrecht, which may be thus expressed. "If you stand with the high barometer to your right hand and the low to your left, the wind will blow on your back." The course of the isobars on a chart, therefore, indicates the direction of the wind, just as the distances between these lines indicate its strength. But the connection between changes of weather and pressure of the atmosphere is by no means well understood. There is, however, one reason which may to some extent explain why the barometer is lower in wet weather than in dry, namely, that, inasmuch as moist air is lighter than dry air, wherever a large amount of aqueous vapour has displaced a part of the

drier air, the barometric column will read relatively low.

This may be illustrated by the following example. A cubic foot of dry air at 32° Fahr. and 30 inches of mercury weighs 566·85 grains. But as air expands $\frac{1}{491}$ of its volume for every degree rise Fahr., the volume at 60° Fahr. would be increased to $1 + \frac{1}{491} \times (60 - 32) = 1{\cdot}057$ cubic foot. Hence, as weight is inversely as volume, a cubic foot of dry air at 60° Fahr. would weigh $\frac{566{\cdot}85}{1{\cdot}057} =$ 536·28 grains. Again, the weight of a cubic foot of vapour at 60° Fahr. is 5·77 grains, but dry air expands on taking up moisture, and the actual weight of a cubic foot of saturated air at 60° Fahr. is 532·84 grains, or 3·44 grains less than the weight of the volume of dry air. This explains the fall of the barometer when the moisture in the air is increasing and rain is imminent, though, as has already been pointed out, the direction of the wind is always an important factor.

2. *Temperature.*—The thermometers used in meteorological observations are of various kinds, but all of them consist of a long glass tube of very small bore, closed at one end and blown out at the other into a bulb or reservoir, which is filled with mercury or some other liquid. The temperature is indicated by the expansion or contraction of this liquid, and is measured by the length of the thread of liquid which extends from the bulb into the tube. The three principal thermometer scales are the *Fahrenheit*, used in this country and America; the *Centigrade*, now generally used on the Continent; and the *Reaumur*, formerly much used in Germany. The freezing-point, or point at which ice melts, is marked on the Fahrenheit scale at 32°, and at 0° in both the centigrade and the Reaumur scales, while the point at which water boils at 29·905 barometer pressure is marked at 212° on the Fahrenheit, 100° on the centigrade, and 80° on the

Reaumur. The degrees, therefore, into which these scales are respectively divided between these two points are 180, 100, and 80; and hence the formula of reduction from any one scale to either of the other two is:—

$$\frac{F-32}{9}=\frac{C}{5}=\frac{R}{4}$$

In the two last any degree of temperature below freezing-point is represented by a *minus* sign, while in the Fahrenheit scale the minus sign is only used for temperatures lower than 32° below freezing-point.

All thermometers used for scientific purposes should be thoroughly tested, and be accompanied by a Kew certificate. The instruments which are generally used are the following—(1) the dry bulb thermometer of a Mason's hygrometer, which will be subsequently described, furnishes the temperature of the air in the shade; (2) a maximum self-registering thermometer for indicating the highest temperature of the air reached in the shade; and (3) a self-registering minimum thermometer for registering the lowest temperature of the air in the shade.

In the *maximum* thermometer the tube is slightly bent and contracted close to the bulb in such a way that, while the expansion of the mercury is sufficient to force the liquid past the obstruction, it is not drawn back again when the temperature falls. It therefore remains broken, as it were, at the point of contraction, so that the thread of mercury left in the tube represents the precise amount forced past the contraction when the temperature was highest, and the maximum reading is taken at the end of the thread.

In order to set this thermometer, it should be held bulb downwards, and shaken, when the thread of mercury will return and become continuous with the mercury in the bulb, and it will then indicate the same temperature

as that of the air. The instrument should be hung at an angle slightly differing from the horizontal, with the end of the tube downwards.

The *minimum* thermometer generally used is an alcoholic thermometer with a small metallic index which moves with little difficulty in the tube. It is set by sloping the instrument with the bulb uppermost, and thus allowing the index to slide nearly to the end of the spirit, and when so set it should be placed in a nearly horizontal position. As the spirit contracts during cold it carries the index with it back towards the bulb, and when it expands again the spirit flows past without moving it, and thus leaves it at the degree of greatest cold. The reading is taken at the end of the index farthest from the bulb.

Both these instruments should be placed in a screen standing four feet above the level of the ground, but not under the shadow of any trees, nor within twenty feet of any wall. The stand recommended is that of the Meteorological Society, the screen of which is so constructed that while it admits of free ventilation, it protects from sunlight and wet.

The *sun maximum*, or *solar radiation, thermometer*, consists of a glass case from which the air has been exhausted, and containing a mercurial thermometer with a blackened bulb which absorbs the sun's rays. The thermometer resembles the *shade maximum* thermometer already described, and is set, hung, and read in the same way. It should be freely exposed to sun and air on a stand about four feet from the ground, at a distance from walls or trees, and with the bulb directed to the south-east. The greatest amount of radiation which has occurred during the day is indicated approximately by the difference between the maximum temperature of the air in the shade and the maximum temperature registered

by the solar radiation thermometer. The *minimum*, or *terrestrial radiation, thermometer*, resembles the ordinary minimum thermometer, but is protected by a glass shield. It is exposed on grass, which should be kept closely cut, or on a black board close to the ground. The difference between the minimum temperature so registered and the minimum in the air is taken as the amount of terrestrial radiation.

In recording temperature the dry bulb of the *dry and wet bulb* thermometer is read as a common thermometer. The approximate mean daily temperature may be obtained by taking observations at certain times during the day and applying Glaisher's corrections. For example, if the temperature be taken at 7 A.M., 2 P.M., and 9 P.M., and t, t', t'', denote the temperature at these hours respectively, then the mean temperature of the day will be $\frac{t + t' + 2t''}{4}$; or if the hours be 8 A.M., 3 P.M., and 10 P.M., the formula is $\frac{7t + 7t' + 10t''}{24}$. In many places the *mean temperature* of the day and year is derived solely from the mean of the shade maximum and minimum, and this approximates nearly to the truth. At Greenwich and other observatories, where the height of the thermometer is registered by photography at every moment of the day, the mean of the hourly readings is taken. Or if the temperature be taken twice a day at homonymous hours, such as 9 A.M. and 9 P.M., the mean of these observations do not differ much from the true daily mean (Scott). The *mean daily range* of temperature is obtained by deducting the average daily maxima from the average daily minima temperatures. The *extreme daily range* in the month or year is the difference between the maximum and minimum thermometer on any one day. The *extreme monthly* or *annual range* is the difference between the greatest and lowest recorded temperatures in the month or year. The *mean monthly range* is the sum of the daily

ranges divided by the number of days in a month, while the mean annual range is the sum of the monthly ranges divided by 12.

On land the lowest temperature is about 3 A.M. or just before sunrise, and the highest about 2 P.M. The extreme daily range is greater on land than on water, in the interior of continents than by the sea-side, and in elevated regions than at sea level. The annual range is also greater on land, and is highest in the interior of great extra-tropical continents.

The temperature of any locality, as has already been explained, is influenced by geographical position, by the relative amount of land and water, by elevation above sea level, by aspect and exposure, and by the nature of the soil and the amount of vegetation. So far as surface is concerned, the best reflectors are the worst absorbers of heat. The nearer the colour of the ground approaches to white, the greater will be the sun warmth and the cooler the air; while the darker the colour, the warmer will be the air, and the less will the heat of solar radiation be felt. The temperature, too, is greatly influenced by the amount of moisture contained in the soil. Moist and clayey soils are cold because the heat is absorbed by evaporation, while dry hard rocks and dry sands and gravels are warm. According to Buchan, the mean temperature of arable land is raised nearly 1° Fahr. by drainage, and the temperature is rendered much more equable. Hence it is, as shown by the researches of Drs. Buchanan and Bowditch, that drainage exercises such an important influence on the diminution of phthisis. As regards the influence of vegetation, it may be said generally that while this covering prevents the soil from being heated to the same degree as dry sand or bare rock, the air itself is cooled by the process of evaporation which is constantly going on from the foliage. Peat and marsh lands are

specially characterised by a low annual temperature, and their surfaces are often covered with mists.

Lines drawn on charts connecting places with the same mean annual temperature, as first proposed by Humboldt, are called *isothermal lines.* If there were no causes leading to deviations, these lines would be parallel to the equator, but as shown on a map they exhibit wide fluctuations, curving towards the north in some regions and towards the south in others. They further show that north of the equator there is a great difference between the course of the winter, the summer, and the annual isothermals. The winter isothermals rise considerably in a northerly direction in the northern Atlantic, in the British Isles, and the west coast of Norway, and descend or curve towards the equator in the interior of the continents of Asia and America, while the summer isothermals exhibit an opposite course. In the southern hemisphere the isothermals do not manifest such wide fluctuations, on account of the much greater proportion of water to land, and with increasing distances from the equator they become almost parallel.

3. *Humidity.*—The amount of watery vapour or the hygrometricity of the air may be determined by hygrometers such as Daniell's and Regnault's, but the instrument generally used in this country is known as Mason's *dry* and *wet bulb thermometer,* which really consists of two thermometers, both bulbs of which project below the scales. At meteorological stations the instrument is usually placed in the same screen as the maximum and minimum thermometer, and therefore under the same relative conditions as to height from ground, etc. The wet bulb is covered with muslin, over which there is twisted a small skein of lamp cotton which dips into a little vessel containing either rain water or distilled water. The cotton should be boiled in ether or soaked

in a solution of sodium carbonate, to free it from fat, so that the water may readily ascend by the force of capillary attraction and keep the bulb moist. The muslin and cotton should be renewed once or twice a month, and care should be taken to regulate the supply of water in the little reservoir. This should be placed at some distance on the off side of the wet thermometer and as far as possible from the dry. When the temperature of the air is below the freezing-point, the passage of water along the cotton is arrested, and it is then necessary to moisten the wet bulb with cold water some time before the hour of observation so as to allow the moisture to freeze.

The principle of action of this hygrometer depends upon the fact that so long as the atmosphere is not saturated with moisture, evaporation will take place on any free surface such as the moist covering of the wet bulb, and heat is abstracted. If, however, the air is saturated, no evaporation is possible, and the two thermometers, the dry and the wet bulb, will read alike, and the temperature then noted is the *dew-point.* Occasionally, as in a thick fog, or during cold, calm weather, the wet bulb may read slightly higher than the dry bulb, and when this occurs, the reading of the dry bulb, according to Scott, should be taken and considered as the point of saturation. The dew-point, then, is the temperature of the air when it is so saturated with moisture that the least cooling will cause condensation or deposit of water. If the dry and wet bulbs are not of the same temperature, the dew-point is always more or less lower than the temperature of the wet bulb, and it can be calculated by what is called Apjohn's formula, or usually and more conveniently by Glaisher's table of factors, from which the following are selected as examples :—

Reading of Dry-bulb Therm.	Factor.	Reading of Dry-bulb Therm.	Factor.
50°	2·06	70°	1·77
51°	2·04	71°	1·76
52°	2·02	72°	1·75
etc.	etc.	etc.	etc.

The rule of calculation is to take the difference between the dry and wet bulb and multiply it by the factor which stands opposite the dry bulb temperature, then deduct the product from the dry bulb temperature, and the result is the dew-point. To apply Apjohn's formula, a table of the elastic tension of vapour in inches of mercury at different temperatures is required. Let f' be the elastic tension corresponding to the temperature of the wet bulb, $(t-t')$ the difference between the dry and wet bulb thermometers, and p the observed height of the barometer, then f'', the required elastic tension of the dew-point, is calculated as follows :—

$$f''=f'-0·01147 \quad (t-t') \ \frac{p-f'}{30}$$

but as the fraction $\frac{p-f'}{30}$, differs but little from unity, it may be disregarded, and the formula then becomes

$$f''=f'-\frac{(t-t')}{87}$$

for the temperature above 32° Fahr., and if below 32° the formula is

$$f''=f'-\frac{(t-t')}{96}$$

When the elastic tension is thus obtained, by looking at the table we find opposite to it the dew-point temperature.

The dew-point having been ascertained, the weight of a cubic foot of vapour, and the amount of *vapour tension,* or *the absolute humidity,* can also be ascertained from tables.

As has already been explained, the *relative humidity*

is merely a convenient term to express dryness or moisture of the air. Complete saturation being assumed to be 100, the relative humidity is expressed by the proportion of vapour actually contained in the air to the amount which it could contain when fully saturated. The relative humidity corresponding to different temperatures of the dry and wet bulb, as well as the weight of a cubic foot of dry air, or of dry and moist air, are all given in Glaisher's Hygrometrical Tables.

A modification of what is called the Saussure's hair hygrometer is generally used in Norway and Russia, and is recommended where extreme severity of climate is met with. It consists of a human hair freed from fat by steeping it in ether or a solution of liquor potassæ, one end of which is fixed, and the other is attached to a small needle, and according as the hair becomes shorter or elongates, the needle traverses a graduated scale, and thus indicates the relative humidity. After a time, however, it loses its delicacy, and requires to be readjusted.

4. *Rainfall.*—The amount of rainfall is measured by a rain gauge, containing a circular collecting funnel fitted with a vertical rim about six inches deep, and a can in which the rain is caught. The diameter of the rim of the funnel recommended by the Meteorological Department is eight inches. The gauge should be fixed firmly into the ground by means of four short stakes, and the top of the rim should be about twelve inches above the surface. It should be set up in a well-exposed position, and as far from a neighbouring object, as a wall or tree, as that object is high.

At stated times (usually at 9 A.M.) the top is taken off, and the can emptied into a glass vessel graduated to hundredths of an inch, which accompanies the gauge. When snow has fallen it should be melted before it is measured; or if the fall is deep, an approximate estimate

may be obtained by measuring the depth of snow in inches, and taking one-twelfth as representing the rainfall. The fall of an inch of rain implies that over a given area rain has fallen to the depth of one inch. The average mean annual rainfall of England and Wales is estimated to be about 25 inches, and every inch of rain falling on an acre of space represents 22,622 gallons of water.

5. *Winds.*—The direction of the wind is determined by vanes, or may be ascertained by observing the lower stratum of clouds. The velocity can be approximately estimated by Robinson's anemometer, which consists of four small cups fixed at the ends of horizontal axes of such a length that 500 revolutions indicate one mile. By means of clockwork and a dial the number of miles traversed by the wind in a given time can thus be roughly determined. Osler's anemometer, which is much more complicated, registers on a piece of paper fitted on a drum the direction, velocity, and pressure. The velocity is reckoned as so many miles per hour, and the force as so many pounds, or parts of a pound, on a square inch of surface. If the velocity is known, the pressure can be ascertained by multiplying the square of the velocity per hour by ·005.

In this country the average velocity of the wind near the surface of the earth is from 6 to 8 miles an hour. In heavy winds it rarely exceeds 45 miles, or in a hurricane 80 miles an hour. The following table from Buchan's *Meteorology* gives a fairly approximate estimation of the velocity of the wind in relation to force and pressure:—

Estimated Force.	Pressure in lbs. per sq. ft.	Velocity in miles per hour.	Popular Designation.	Estimated Force.	Pressure in lbs. per sq. ft.	Velocity in miles per hour.	Popular Designation.
0·0	0·00	0·0	Calm.	3·0	9·00	42·4	Very fresh.
0·1	0·01	1·4	Lightest breath of air.	3·5	12·25	49·5	
				4·0	16·00	56·6	Blowing hard.
0·5	0·25	7·1	Very light air.	4·5	20·25	63·6	
1·0	1·00	14·1	Light air.	5·0	25·00	70·7	Blowing a gale.
1·5	2·25	21·2	Light breeze.				
2·0	4·00	28·3	Fresh ,,	5·5	30·25	77·8	Violent gale.
2·5	6·25	35·4		6·0	36·00	84·8	Hurricane.

6. *Clouds.*—Clouds, as recognised by meteorologists, have been classified into three primary, and four compound, types. The primary types are the *cirrus*, the *stratus*, and the *cumulus*. The *cirrus*, or mare's-tail cloud, is a streaky cloud, like a feather or spray, which appears at a very great height in the atmosphere, and is generally regarded as a sign of wind. The *stratus* is a sheet or layer of cloud, usually of uniform thickness, and belongs essentially to the lower regions of the atmosphere. It is generally a fine weather cloud, appearing during the evenings and mornings of the brightest days. All low detached clouds which look like lifted fog, and present little variety of light, shade, or definite form, belong to this type.

The *cumulus* is a very common form of cloud, and consists of rounded masses resting on a horizontal base. It is produced by an ascending current of air, the vapour of which is rapidly condensed, and has a tendency to collect in rudely globular masses, like the stream escaping from a locomotive on a frosty day.

The compound types are the *cirro-stratus*, the *cirro-cumulus*, the *cumulo-stratus*, and the *cumulo-cirro-stratus* or *nimbus*. The *cirro-stratus* is usually generated by

increased condensation in the *cirrus,* which consequently sinks to a lower level, and is generally the precursor of bad weather. The *cirro-cumulus* presents the appearance of small detached rounded masses of cloud, and forms the well-known "mackerel sky." The *cumulo-stratus* is generally dark and flat at its base and traversed by horizontal lines of dark cloud. It is a variation of the *cumulus* changing into the *nimbus,* or *cumulo-cirro-stratus,* familiarly known as the rain cloud. Indeed, the *nimbus,* whilst on the horizon, or as it advances towards the observer, frequently presents the appearance of a very heavy *cumulo-stratus* fringed with falling rain and with some *cirrus* above. When it has covered the whole sky, it is so concealed by falling rain that it generally assumes a uniform dark appearance.

But in addition to the form of clouds, it is equally important to observe their course of motion. Generally speaking, the clouds of the lower stratum of air move in the same direction as the wind on the surface, except in mountainous districts, where winds are affected by local eddies. But at all times even the lowest clouds move far more rapidly than the winds near the surface of the ground. As regards the upper clouds, however, the case is very different, for they generally move in a direction different to the course of the wind on the surface; and by studying their motion much light has been thrown on the currents of air in the upper regions. There are good grounds for believing that these upper clouds are frequently composed of particles of ice. The lower clouds, on the other hand, namely, the *stratus, cumulus, cumulo-stratus,* and *nimbus,* are usually composed of condensed vapour.

In estimating the amount of cloud, a system of numbers is adopted from 0 to 10, 0 expressing a cloudless sky and 10 a sky completely overcast. The pro-

portionate amount of cloud observed is recorded by intervening numbers, but without any reference to the thickness of cloud.

7. *Electricity.*—The various modes of testing the amount and kind of electricity present in the air also leave much scope for further research, and hitherto have led to little practical result. All that is expected of the ordinary meteorological observer is to note the occurrence of lightning and thunderstorms. For estimating the density of electricity existing in the air under ordinary circumstances, and whether it is positive or negative, the instruments which are now generally used are Sir William Thomson's Electrometer (see Scott's *Meteorology*).

8. *Hours of Observation.*—For volunteer observers the combination of 9 A.M. and 9 P.M. has been selected as the most suitable for recording observations throughout the United Kingdom, and the average of the readings of the maximum and minimum thermometers at these hours may be taken as approximating very closely to the true daily mean. (See *Official Instructions* prepared by R. H. Scott, F.R.S., Director of the Meteorological Office.)

Section III.—Climate and Weather Changes in Relation to Health

1. *Climate.*—Although there can be no question that the human organism possesses wonderful powers of adaptability to extremes of climatic conditions, it is equally true that the various races of mankind have their prescribed salubrious limits. Thus it is found that the white races attain their highest degree of physical development and the greatest average duration of life above 40° of latitude in the western, and 45° in the eastern, hemispheres, and whenever they emigrate to regions many degrees below these lines they begin

to deteriorate, owing to the increased temperature and to other conditions which are more or less dependent upon excessive heat. For the effects of a tropical climate are to a large extent relative, inasmuch as the temperature and humidity of the air are highly favourable to putrefactive change, and tend to intensify those pollutions of air and water which are so inimicable to health in all climates. Then, again, there can be little doubt that much of the ill health from which Europeans suffer in tropical climates is largely due to errors in diet, and particularly to over-indulgence in alcoholic drinks, and to the eating of too much animal food.

When the temperature of the air approaches, or even exceeds, as it sometimes does, the temperature of the blood, metabolism is diminished, because there is little call made upon the heat-producing powers of the body, and therefore less food is required. The amount of urine and the amount of urea in the urine are both lessened, as well as the amount of carbonic acid exhaled from the lungs, while the oxygenation of the blood is diminished owing to the lessened number of respirations. On the other hand, the skin acts much more vigorously than usual, and in newcomers the consequent local hyperæmia often becomes painfully manifest in the eruption familiarly known as "prickly heat." After a time, however, the skin becomes altered in structure and yellowish in colour, owing to the deposition of pigment in the deeper layers of the cuticle. Apart altogether from malarial or other unwholesome conditions, it may be said generally that the continued effects of residence in a tropical climate result in sluggishness of body and mind, enfeeblement of health, the premature advance of old age, and a shortening of the average duration of life.

The most enervating effects of heat are experienced when the heat is continuous, and when it is combined with

great humidity of the atmosphere. A shade heat of 90° to 100° is very overpowering, and the same persons who could sustain prolonged hard work in a sun heat of 110° to 120° would speedily become exhausted in a shade heat of 95°. Then, too, a much greater degree of heat can be borne when the air is in movement than when it is perfectly still, and it is certain that sunstroke rarely occurs in high elevations or in mid-ocean, where the sun-heat is often excessive.

With regard to the effects of living in a cold climate, there can be no doubt that with a sufficiency of food and warm clothing healthy persons can withstand even the extreme asperities of the Arctic regions. But to maintain the temperature of the body, tissue change must be rapid; more food, and especially carbonaceous food, must be taken; the circulation and respiratory movements are quickened; and the mental and bodily vigour appear to be increased. People from this country who emigrate to colder regions, such as Canada and Nova Scotia, not only enjoy good health, but produce a progeny perhaps even more vigorous than the parent stock, owing to the active out-door lives which they lead. On the other hand, there is a general consensus of opinion that they do not flourish in climates with an average temperature of 20° higher than their own, and that the race dwindles and finally dies out.

Although atmospheric moisture exercises important influences on bodily function, it is very difficult to estimate these influences apart from those depending on temperature, atmospheric pressure, movement of air, and other conditions. Great humidity of the air impedes the evaporation from the skin and lungs, and when this is associated with a high temperature, the cooling of the body is so much interfered with that there is very often a slight increase in the blood temperature. Hence it is

that the moist siroccos, which are almost saturated with watery vapour, become so oppressive to man and beast. In dry warm air, when the heat is not excessive, the skin parts with much moisture; in dry cold air, on the other hand, the loss by evaporation through the lungs is greatly increased. In temperate climates the most agreeable degree of humidity for healthy persons is about 75 per cent of saturation. Invalids suffering from chronic lung diseases, such as bronchitis, emphysema, and some forms of phthisis, prefer a warm, equable, and moist climate, because a dry atmosphere causes cough and irritation, no doubt owing to the increased evaporation thrown on the lungs.

Atmospheric moisture has a further important bearing on public health, inasmuch as it is a most potent factor in the spread of malarial and filth diseases. A dry atmosphere checks putrefactive change, while a warm moist atmosphere greatly increases it; hence it is that summer diarrhœa in temperate climates often shows no unusual increase, even during very hot weather, if the degree of humidity remains comparatively low. If, however, the weather continues warm and the air moist, summer diarrhœa is certain to become more prevalent.

The climate of islands and of localities near the sea-shore differs from that of the interior of continents in being much more equable, not only as regards seasonal variations, but in respect to the variations of temperature between day and night. Hence has arisen the subdivision of climates into insular or moderate, and continental or excessive.

Then, again, climate is largely influenced by altitude. The climate of hill stations in tropical countries is rendered enjoyable and salubrious compared with that of the plains owing to the reduction of temperature, combined with other conditions, such as greater move-

ment of the air, greater purity, more sunlight, greater dryness, and an increased amount of ozone. Although the weight of oxygen in a cubic foot of air is decreased in high altitudes, the oxygenation of the blood is decreased because the respirations become more frequent and are of greater depth. The action of the heart is also increased, and tissue change is stimulated, leading to increased bodily activity. These beneficial effects of residence at high altitudes have led to the treatment of phthisis at mountain resorts, and with marked success in the earlier stages of the disease. Other diseases which are greatly benefited by mountain air are anæmia, gout, rheumatism, impaired digestion, and neuralgia.

When the climate of particular stations is considered, it is generally found that it is regulated mainly by the influence of the wind. A station which is sheltered from cold winds by a range of hills, a cliff, or even a belt of trees, and is open to warm winds and possesses a southern aspect, presents favourable conditions as a winter health resort. Easterly winds in this country are very trying to healthy persons. and often very fatal to the old and young. When dry they act injuriously by causing rapid evaporation of moisture from the skin and lungs and diminishing the bodily heat. When cold and moist the bodily heat is abstracted from the skin and lungs by conduction and not by increased evaporation. It is on this account that a combination of great cold and fog is felt so keenly.

2. *Weather Changes.*—Cold is the most common cause of disease in the fickle climate of this country. Even a momentary exposure to a cold draught of air is as frequent an excitant of disease as general exposure for a long time. At least one-half the number of patients who apply for treatment at our hospitals and public dispensaries during the winter months are afflicted with colds, coughs, and bronchial or rheumatic affections. The

prevalence of diseases of the respiratory organs at this season, though due in great measure to the lowered temperature, is no doubt also partly attributable to the excessive moisture of the air, and when this is associated with low barometric pressure conditions inimical to health are still further intensified. But apart from any effects due to temperature, it has long been a popular belief that old wounds, diseased bones, and rheumatic joints are very sensitive, and often become painful on the approach of a storm, which in this country would be indicated by a sudden lowering of the barometric column by at least half an inch. This is explained by the fact that the principal effect of diminished atmospheric pressure is distension of the capillaries.

As regards seasonal influence, the researches of the late Dr. Edward Smith possess an important bearing. He found, for example, that the activity of the vital processes varied in a very definite manner,—the maximum being in spring, the decline and minimum in the summer, the minimum and the increase in the autumn, and a stationary elevation in the winter. Even with the same amount of exertion, less carbonic acid is apparently evolved in summer than in winter.

Mild winters and cold summers both lower the mortality; while, on the other hand, a rise of mean temperature in the summer or a fall in winter is followed by an increased amount of sickness and a high mortality. Then, again, it is well known that diseases of the digestive organs exhibit a greater prevalence in summer and autumn, and diseases of the respiratory organs during winter and spring.

The following table, abridged from the late Mr. Netten Radcliffe's article in Quain's *Dictionary of Medicine*, shows the seasonal mortality of the more important diseases current in London during a series of years:—

	Winter.			Spring.			Summer.			Autumn.		
	Jan.	Feb.	March.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
Small-pox	+	+	+	+	‡	+	−	−	=	−	−	−
Measles	+	−	−	−	+	‡	+	−	−	−	+	‡
Scarlatina	−	−	−	−	−	−	−	+	+	‡	+	+
Diphtheria	+	+	−	−	−	−	−	−	+	+	‡	‡
Croup	+	+	+	+	−	−	−	−	−	−	+	+
Whooping Cough	+	+	+	+	+	−	−	=	=	=	−	+
Typhus (6 years)	+	+	+	+	−	−	+	−	−	+	−	+
Typhoid (6 years)	+	+	−	−	−	=	−	+	+	+	‡	+
Simple continued fever	+	+	‡	−	−	+	−	−	+	−	−	+
Erysipelas	+	+	−	−	−	−	−	−	−	+	‡	‡
Diarrhœa	−	−	−	−	−	−	‡	‡	+	−	−	−
Rheumatism	+	+	+	+	+	−	−	−	−	−	+	+
Gout	+	+	+	+	+	−	−	−	−	−	−	−
Phthisis	+	+	+	+	+	−	−	−	−	−	−	+
Heart Disease	+	+	+	+	−	−	−	−	−	−	+	+
Bronchitis	‡	+	+	+	−	−	−	=	−	−	+	+
Pneumonia	+	+	+	+	−	−	−	=	−	−	+	+
Pleurisy	+	+	+	+	−	−	−	=	−	−	+	+
Old Age	‡	+	+	+	−	−	=	−	−	−	−	+

\+ Above the average. ‡ Maxima.

− Below the average. = Minima.

It will be seen from this table that if illustrated diagrammatically the curves of typhoid fever, diphtheria, and erysipelas would be very similar. Typhoid fever is least prevalent in late spring and early summer, and becomes most prevalent in the autumn. The table also shows that the curve for scarlatina resembles that of typhoid as to the period of its maximum death-rate, but the minima of these two diseases diverge widely. The curve for whooping-cough closely approaches those for pneumonia, bronchitis, and other lung diseases, because all of them are greatly influenced by mean temperature. They increase in prevalence as the temperature falls, and diminish as it rises. The curve for diarrhœa, on the other hand, rapidly sweeps upwards in July, and falls as

rapidly when the lowered temperature of the autumn sets in.

As regards seasonal influence on total mortality, it may be laid down as a rule that the general death-rate is highest in the first quarter of the year and lowest in the third—the order from highest to lowest being first, fourth, second, third, but in many districts this sequence is found to vary considerably, and occasionally varies in respect to the country generally.

CHAPTER VII

WATER

SECTION I.—SOURCES

ALL supplies of fresh water are derived from the condensation of the aqueous vapour contained in the atmosphere. Whether this falls to the earth in the form of rain or snow, a certain portion of it runs off the surface and gravitates towards the sea; another portion sinks into the soil, and, passing through strata which are more or less porous, or through fissures in rocks, again reappears in springs and wells; a third portion is evaporated where it falls; and the remainder becomes absorbed in the chemical composition of minerals, or is utilised in the processes of growth and decay of animal and vegetable life.

The rainfall which flows on the surface collects in streams, lakes, and rivers, according to the conformation of the ground, while the water flowing under ground oozes to the surface either imperceptibly or in springs, and eventually unites with the surface water in its accumulation in lakes, or in its onward progress towards the sea.

The immediate sources of water-supply may therefore be classified as rain water and water from springs, wells, rivers, or lakes.

1. *Rain Water.*—Rain water is highly aerated, and, when uncontaminated by the receiving surface or by air impurities, is healthy and pleasant. But frequently,

according to the analyses of the Rivers Pollution Commissioners, it contains a large amount of organic matter, and in this country is usually far less pure than water derived from deep wells and springs. This is not to be wondered at when we consider that the atmosphere in a thickly populated country like Great Britain becomes the recipient of vast quantities of excremental dust and effluvia, of smoke particles, and the products of animal and vegetable decay. It is therefore seldom stored on premises except for washing purposes; but in Venice and many other Continental cities it is collected in underground reservoirs, and constitutes almost the sole source of fresh-water supply to the inhabitants. It is usually collected from the roofs of houses, and occasionally from paved or cemented ground. In hilly districts with deep ravines it may be stored by carrying an embankment across a valley, or, in level districts, by digging a series of trenches or adits leading to a tank or reservoir.

The amount of water derivable from the rainfall in given cases is readily ascertained, if the mean annual rainfall of the district is known, and the dimensions of the receiving area are obtained. Thus, when the roofs of houses constitute the receiving area, the transverse section of the buildings will be one factor, and the mean annual rainfall the other. It has been estimated that the quantity which can be collected from the roof surface of any town in this country will scarcely amount to 2 gallons per inhabitant daily, assuming that the average rainfall is 20 inches, and that house accommodation gives a roof area of 60 square feet for each individual. The following table, by W. Sowerby Wallis, F.M.S., shows the daily yield of water from a roof with varying rainfalls:—

Area of House, 10 feet by 20 feet, or 200 square feet.					
Mean Rainfall.	Loss from Evaporation.	Requisite capacity of Tank.	Mean daily yield of Water.	Mean daily yield of Water in wettest year.	Mean daily yield of Water in driest year.
inches.	per cent.	cubic feet.	gallons.	gallons.	gallons.
20	25	100	4·3	6·7	3·2
25	20	135	5·7	7·5	3·9
30	20	145	6·8	9·4	4·5
35	20	155	7·9	11·0	5·0
40	15	165	9·7	13·1	7·2
45	15	170	10·9	14·2	8·6

For any other size of roof or amount of rainfall, the numbers will be proportional.

If, instead of the roof-surface, a cemented piece of ground is the receiving area, the superficial area in square yards, multiplied by the rainfall in inches, and this again by 4·673, will give the total number of gallons, because one inch of rainfall delivers 4·673 gallons on every square yard.

If lines be drawn through the sources of the tributaries of rivers marked on a map, they will be found to form the boundaries of certain areas which are called the catchment basins of the various rivers—that is, the areas which receive the rainfall supplying their waters. In compact formations, where most of the rain runs off the surface, the ridge lines bounding these basins usually pass along the most elevated regions, but in porous formations their course will depend on the configuration of the retentive substratum.

The amount of rainfall which penetrates beneath the surface varies according to the density and configuration of the ground, and also depends on whatever influences the rate of evaporation. Thus in loose sandy or gravelly districts as much as 90 to 96 per cent sinks into the soil; in chalk districts, 42; in limestone, 20; while in districts of retentive impermeable clay the percentage is

very small. Dr. Dalton, in his experiments on the new red sandstone soil of Manchester, found that 25 per cent of the whole rainfall penetrated to the depth of 3 feet; and Mr. Prestwich gave the amount of infiltration of the principal water-bearing strata surrounding London as varying from 48 to 60 per cent.

Other things being equal, the amount of infiltration will be far less in an undulating hilly district than in open level plains. It is obvious also that it must vary very considerably with the season of the year. Thus, according to the experiments of Mr. Dickinson, made in the gravelly loam which covers the chalk in the valleys around Watford, it was 70 per cent in the first three months of the year; in the summer months it was only 2; while in November and December nearly the whole of the rainfall penetrated beneath the surface.

2. *Water from Wells, Springs, Rivers, and Lakes.*—The quality and composition of the water derived from these sources depend on the nature of the soil and geological strata through which it has passed, or on the character of its surface-bed or channel. The rain, already charged with carbonic acid in its passage through the lower regions of the atmosphere, becomes still more largely impregnated with this gas when it sinks beneath the surface. In some rich soils the amount present in the air contained within their interstices, according to Boussingault, is 250 times greater than the ordinary atmospheric ratio. Aided by the action of the carbonic acid which it has thus absorbed, the rain water dissolves and decomposes various chemical compounds which it meets with in its underground progress, and often becomes so highly charged with them as to become unfit for ordinary use, as in the case of mineral waters.

(1.) Surface or shallow-well waters, though sometimes comparatively pure, frequently contain a large

amount of organic matter. In mossy moorland districts, for example, or in rich vegetable soils, the water may contain from 12 to 30 grains of vegetable matter per gallon, which imparts to it a yellowish or brownish tint; while in marshy districts the amount of organic matter varies from 10 to 100 grains. The saline constituents depend very much upon the geological character of the stratum in or upon which the well is sunk, but in inhabited places these are often masked by the products of excremental pollution. Shallow well waters are drawn from wells not more than 50 feet deep, and seldom exceeding half that depth. Surface waters from cultivated land are always more or less contaminated with manurial impurities, and should therefore be regarded as extremely suspicious waters.

(2.) The water from deep wells and springs varies according to the geological strata through which it passes. Thus alluvial waters are more or less impure, containing a large amount of salts (20 to 120 grains per gallon) and often much organic matter; while the chalk waters are clear, wholesome, and sparkling, holding in solution a considerable amount of calcium carbonate besides other salts, and being largely impregnated with carbonic acid. Also wholesome and agreeable to the taste, but not so suitable for cooking purposes, is the water from the limestone and magnesium limestone strata. It contains more calcium and magnesium sulphate than the chalk water, and consequently does not become so soft on boiling. Waters from the granitic, metamorphic, trap-rock, and clay-slate formations are generally very pure, and contain but small quantities of solids, consisting chiefly of sodium carbonate and chloride, with a little lime and magnesia. Waters from the millstone grit and hard oolite are also very pure. The saline constituents are by no means excessive, and are chiefly in the form of calcium

and magnesium sulphate and carbonate, with traces of iron. Soft sand-rock waters, loose sand and gravel waters, and waters from the lias clays vary very much in quality and composition, some of them being very pure, as the Farnham waters, and others containing large amounts of mineral and organic matters.

(3.) River water is in most cases softer than spring or well water. It contains a smaller amount of mineral salts, but is often largely impregnated with organic matter on account of the vegetable *débris* and animal excreta which find their way into it. Its constant movement, however, facilitates the oxidation of organic impurities, and this purifying process is aided to some extent by the presence of fresh-water plants.

(4.) Lake water, especially in mountainous districts composed of the older rock formations, is generally very soft, containing little mineral matter; but as it is essentially a stagnant water, and as all lakes receive the washings of the districts in which they are situated, the amount of organic nitrogenous matter is sometimes very considerable. Any excess, however, of peaty matter in solution may be materially lessened by filtering through sand.

As regards the qualities of potable waters founded upon their respective sources, the following classifications are given by the Rivers Pollution Commissioners in their Sixth Report:—

a. In respect of wholesomeness, palatability, and general fitness for drinking and cooking:—

Wholesome.	1. Spring water.	Very palatable.
	2. Deep-well water.	
	3. Upland surface water.	Moderately palatable.
Suspicious.	4. Stored rain water.	
	5. Surface water from cultivated land.	Palatable.
Dangerous.	6. River water to which sewage gains access.	
	7. Shallow-well water.	

b. According to softness:—

1. Rain water.
2. Upland surface water.
3. Surface water from cultivated land.
4. River water.
5. Spring water.
6. Deep-well water.
7. Shallow-well water.

c. In respect to the influence of geological formation in rendering water sparkling, colourless, palatable, and wholesome, by percolation, the following water-bearing strata are given as the most efficient:—

1. Chalk.
2. Oolite.
3. Greensand.
4. Hastings sand.
5. New red and conglomerate sandstone.

Section II. Quantity necessary for Health and other Purposes

A healthy adult requires daily from 70 to 100 oz. of water for the processes of nutrition, about one-third of which is contained in articles of diet, the other two-thirds being supplied in the form of liquids. The amount for cooking has been estimated at from half a gallon to a gallon daily for each person, while the quantity deemed necessary for personal cleanliness and for washing purposes will necessarily vary very much according to the habits of the individual.

Prof. Parkes has given the following quantities used by a man in the middle class:—

	Gallons daily.
Cooking	·75
Fluids as drink	·33
Ablution, including a daily sponge-bath . .	5
Share of utensil and house washing . . .	3
Share of clothes washing	3
	12·08

The soldier is allowed about 15 gallons daily, no extra allowance being given for the women and children in a regiment. In the poorer districts of the city of London, Dr. Letheby found that the amount used was 5 gallons per individual daily, and in model lodging-houses, according to Mr. Muir, 7 gallons. In the cottages of the poor, in country districts where water is scarce, the amount in many instances does not exceed 3 gallons, but then the inhabitants are not cleanly. A shower-bath daily will require 3 to 4 gallons, while a plunge-bath will take from 40 to 60 gallons. Where water-closets are used, an additional allowance of from 4 to 6 gallons must be provided. Latrines require a less amount.

In gross amounts Professor Rankine has given an estimate of 10 gallons daily per individual for domestic purposes, 10 for municipal purposes, and 10 more for trade purposes in manufacturing towns, and this amount, large though it seems, is actually supplied to many towns at the present day. Glasgow, for example, receives 50 gallons daily per head of population; Edinburgh and Southampton 35; Paris 31; and Liverpool 30. The different London water companies supply from 21 to 34 gallons—the mean average being 28; while the manufacturing towns in Lancashire and Yorkshire, according to Mr. Bateman, received from 16 to 21 gallons. In Norwich the average supply is only 12 gallons, and in Derby 14. In Warwick, by careful inspection as regards waste, it has been reduced from 22 to 15 gallons per

head daily, and Warwick is entirely a water-closet town. Mr. Rawlinson's minimum estimate for manufacturing towns is 20 gallons per head daily, and if care be taken to prevent needless waste this amount will be more than sufficient.

In apportioning the daily allowance for all purposes, Prof. Parkes has given the following estimate:—

	Gallons per head of population.
Domestic supply	12
General baths	4
Water-closets	6
Unavoidable waste	3
Total house supply	25
Municipal purposes	5
Trade purposes	5
Total	35

No doubt this estimate may be regarded as somewhat excessive, especially in the items of domestic and water-closet supply, but it has been based on the principle that a liberal allowance is not only necessary for thorough cleanliness, but that it is also required for an efficient clearage of sewers. There can be no question, however, that the amount of water habitually wasted in many towns is enormous, reaching in all probability to at least one-third of the supply, and this, when the water has to be pumped into the town, or when the town sewage has to be pumped or chemically treated in any way at the outfall, increases the rates to a very considerable extent. While part of this waste is due to underground leakage from pipes and mains, by far the larger portion of it is due to imperfect household fittings, and to carelessness in leaving stool-cocks and bib-cocks open in connection with water-closets whose flush pipes communicate directly with the mains. All closets should be provided with cisterns

of the waste-preventing class, but of sufficient capacity to flush the closet-pan when used.

For hospitals the daily amount per patient may be estimated at about 30 gallons. In prisons and workhouses the quantity will vary according to the bathing arrangements, and whether water-closets are used. In the Convict Prison, Portsmouth, where water-closets and water-latrines are both in use, and where each prisoner is allowed a general bath once a week, I found that the amount averaged about 11 gallons per convict daily.

Section III.—Modes of Supply

This part of the subject has reference to springs, wells, borings, the collection and storage of water, and to waterworks generally.

1. *Springs.*—Springs are natural outlets of underground water, and are usually divided into land and main springs. Land springs are the outlets of limited collections of underground water formed in beds of gravel or land overlying a stratum of clay. They are often intermittent, and may become dry during the summer months. Main springs, on the other hand, flow from a geological formation overlying an impermeable stratum which crops out on the surface at a lower level than the line of infiltration. Although the flow of main springs is perennial, it is generally subject to seasonal fluctuations, being greatest in February and March, when the level of the underground water stands highest, and least in September or October, when the level of the underground water is lowest. Springs afford good sources of supply for villages or small communities, but when the yield is intermittent or fluctuates considerable storage is rendered necessary.

2. *Wells and Borings.*—In small urban and rural districts surface wells, whether as ordinary pump wells,

draw wells, or shallow dip wells, constitute the usual source of supply, and though they may naturally yield a wholesome water, the surrounding soil often becomes so saturated with impurities that it is next to impossible to prevent their pollution. In crowded localities, therefore, they should always be regarded with suspicion, and, as far as possible, their use should be discontinued. Deep wells, on the other hand, are not open to this objection, because they are generally sunk through an impervious stratum, which prevents the infiltration of any surface impurities, and at the same time serves to keep down the water in the porous strata beneath. The quality of the water from these wells, as has already been shown, will depend on the nature of the geological formation of the district. It is also apparent that, in accordance with a well-known physical law, it is only necessary to bore through the impervious stratum, and reach the water-bearing bed, for the water to rise to the surface, or to within a short distance of it, so as to be collected in a well of ordinary dimensions. Indeed, in certain low-lying districts, where a boring is made at a point considerably below the level of the line of infiltration into the water-bearing stratum, the water rises above the surface and overflows. Such overflowing wells, or artesian wells as they are called, were once common in the valley of the Thames, and are still to be met with in the flat lands of Essex and on the coast of Lincolnshire. Ordinary borings differ from artesian wells in not piercing through a retentive stratum in order to reach the water supply. They are very common in the chalk and new red sandstone districts, and are made to increase the yield of the wells. Practically, it is found that one boring adds to the supply of a well nearly as much as several. Thus in the Bootle well at Liverpool, with 16 bore-holes, some of which were 600 feet deep, Mr. Stephenson found that when all were plugged up but

one, the yield was 921,192 gallons per day, and when all were open it was only increased by 112,792 gallons.

Deep wells are now being abandoned for the supply of large towns, because they are found to be insufficient for the wants of a rapidly-increasing population, and obviously cannot be multiplied within a given district beyond certain limits, because every single well drains a surrounding area of some considerable extent. For large isolated buildings, however, such as lunatic asylums, workhouses, and prisons, they usually supply the whole of the water required; and in selecting a site in the country for any such building, the possibility of obtaining the requisite water-supply, and the cost at which it can be procured, are points of the first importance.

Generally speaking, the chance of obtaining a good supply will depend upon the nature of the underlying strata, and upon the level of the proposed site. Wells sunk in superficial sand or gravel beds, though yielding a good supply at ordinary times, are very liable to have their yield very much lessened in seasons of drought, unless they are situated at points considerably below the level of the surrounding country, and the same remark applies to surface wells in the chalk districts. On the other hand, deep wells or borings in the new red sandstone, and oolite or chalk formations, usually yield a large and constant supply, because these permeable rocks are so saturated with water that they may be regarded as vast subterranean reservoirs. The deepest artesian wells in the world are those at Grenelle in Paris and Kissengen in Bavaria, the former being 1800 and the latter 1878 feet in depth.

The Commissioners, in the report already alluded to, strongly urge "that preference should always be given to spring and deep-well water for purely domestic purposes, over even upland surface water, not only on account of

the much greater intrinsic chemical purity and palatability of these waters, but also because their physical qualities render them peculiarly valuable for domestic supply. They are almost invariably clear, colourless, transparent, and brilliant, qualities which add greatly to their acceptability as beverages; whilst their uniformity of temperature throughout the year renders them cool and refreshing in summer, and prevents them from freezing readily in winter. Such waters are of inestimable value to communities, and their conservation and utilisation are worthy of the greatest efforts of those who have the public health under their charge."

The following are some of the towns which are supplied by deep wells:—Canterbury, Cambridge, Bury St. Edmunds, and Deal from the chalk formation; Birkenhead, Coventry, Leamington, and Southport from the new red sandstone; and Bedford and Scarborough from the oolite.

For a small or temporary supply the tube well has been found to be very useful. It consists of a narrow iron tube driven into the ground in lengths, the lower part being pointed and perforated at its end, and is fitted with a single or double action pump according to the depth. The water enters the tube through the perforations, and, if the bed is sandy, has to be filtered for some time, until, by gradual removal of the sand, a well is formed around the lower end, and the water is obtained without sediment. This pump is especially adapted for country districts, and it possesses the further advantage of helping to keep out surface impurities.

In order to ascertain the yield of surface wells, the transverse area of the well and the height at which the water stands must first be ascertained, after which the water is pumped out, and the time noted which is required for refilling. The yield of small springs can be

readily measured by receiving the water into a vessel of known dimensions, such as a cask, and also noting the time which it takes to fill.

3. *Waterworks.*—In addition to deep wells, waterworks on an extensive scale obtain their supply from lakes, streams, rivers, or gathering-grounds. When lakes are used as reservoirs, they are generally of sufficient elevation above the level of the town to be supplied to permit of the water being distributed to the highest points by the force of gravity; but in order to secure ample storage or prevent undue interference with various vested rights, it is usually found necessary to raise the level of the lake by constructing a barrier at the outlet varying in height according to the area of the lake and the quantity of water required. Thus, in the case of Loch Katrine, which supplies the city of Glasgow, and covers an area of 3000 acres, it was found necessary to construct a barrier 4 feet in height in order that with a maximum lowering of 7 feet it might provide a storage of 5687 million gallons for a supply of 50 millions per day; while Thirlmere, with an area of 350 acres, requires a barrier 50 feet in height to provide a storage of 8100 million gallons for a similar daily supply for Manchester.

If the source of supply is a stream or small river, storage works are necessary; but when the river is large, a constant supply can be obtained at all times, independently of storage. In this case the works required usually comprise—a weir or dam for maintaining part of the river at a nearly constant level; two or more settling ponds, into which the water is conducted; filtering apparatus; and pumping engines.

When it is required to ascertain the yield of any small stream, it is usual to employ a weir gauge to dam up the water into a pond behind, and allow it to flow through a sluice or over a sill of known dimensions. In

the case of an average-sized stream, a rough approximation of the yield may be obtained by taking the breadth and depth at several distances in a short section of the channel which is tolerably uniform, and thus ascertaining the average sectional area. The surface velocity may then be taken by noting the time occupied in floating a light object over the selected distance, and as four-fifths of the surface velocity are about equal to the actual velocity, the yield in cubic feet or gallons per second can be easily calculated (see Appendix).

When the water-supply of a town is collected from small streams or gathering grounds, the rainfall of the catchment basin and its available amount are items which ought to be carefully inquired into. The ratio of the available to the total rainfall, as already shown, is influenced by the nature of the soil, the steepness or flatness of the ground, the rapidity of the rainfall, and other circumstances. Professor Rankine has given the following examples :—

Ground.	Available Rainfall divided by Total Rainfall.
Steep surfaces of granite, gneiss, and slate .	nearly 1
Moorland hilly pastures	from ·8 to ·6
Flat cultivated country	from ·5 to ·4
Chalk	0

The average annual rainfall in different parts of this country varies from 22 to 140 inches, the least recorded depth being 15 inches. It is greater in mountainous than in flat districts, and on the leeward side of a mountain ridge than it is on the side facing the prevailing winds. As regards water supply, the most important data are the least annual rainfall and the longest period of drought.

In selecting drainage areas, it must be borne in mind that the nearer the actual rainfall water is collected the freer it will be from impurities, and that purity of water

and fertility of soil are not to be expected together. Water collected from a peaty soil will contain large quantities of vegetable matter, while that from a soil well cultivated will be tainted with animal impurities. The purest water, therefore, which can be collected from drainage areas is found in the barren moorland districts of the primary geological formations, or of the sandstone rocks.

The channels of the gathering ground may either be the natural watercourses of the district, or these may be supplemented by adits, closed drains, or open ditches. The latter, however, are objectionable because they form receptacles for vegetable matter, and as the current in them must be necessarily slow, there is considerable loss by evaporation. The position, extent, and dimensions of the adits leading to the reservoir will depend upon the configuration of the district. The reservoir itself is generally a natural hollow, situated in the valley-line of the catchment basin, and of sufficient elevation to procure a fall, so that the water can be distributed without mechanical means being required to raise it. In this country the storage-room should be large enough to contain a four or six months' supply; and the site which can supply the requisite storage room with the least embankment, the least amount of puddle, and the least area laid under water, is to be preferred.

Upon the strength and stability of the embankment everything depends. It is made water-tight by a core of clay puddle, the inner slope being protected from the action of the water by a pitching of dressed stones, and the outer from the effects of the weather by a covering of grass sods. The puddle-core generally amounts to a tenth of the whole embankment. The height of the embankment varies from 3 to 10 feet above the highest water level, the top being covered with broken stones.

No trees or shrubs are allowed to grow upon it, and the greatest care is taken in its construction to prevent animals, such as water-rats, burrowing into it.

Every impounding reservoir, as it is called, is provided with an overflow weir to permit the discharge of the flood supply from the drainage area, and this is often supplemented by a channel termed the *by-wash*, which is used to divert the streams supplying the reservoir, so as to prevent fouling of the store-water. The flood-water carried off in this way flows into the natural watercourse.

In order to remove the sediment which collects in the bottom of the reservoir, there is always a cleansing pipe as well as a discharge-pipe, the former being on a level with the lowest point in the reservoir, and discharging into the natural watercourse below the embankment. Both are carried through a culvert in the embankment, which is built of stone or brick, and founded on the solid rock. The aqueduct or discharge-pipe bends upwards in the reservoir, and has a series of inlets, the lowest at the lowest working level, and the whole of them guarded against the entrance of small stones, pieces of wood, or other bodies, which would interfere with the action of the valves. The sluices which are required for both pipes are situated in the reservoir, and are worked from the sluice-tower.

The aqueduct is that portion of the conduit leading from the reservoir to the distributing conduits. It may be open or close throughout, or partly close and partly open. If close, it generally consists of a train of cast-iron pipes securely jointed, bedded on a firm foundation, and covered to a depth of at least 2 or 3 feet, to preserve them from frost. Sluice stop-cocks are provided in the valleys, for the purpose of scouring out any stones or sediment, and, at intervals not exceeding half a mile, to

permit of repairs. Valve-cocks are supplied at all the principal summits, to allow the escape of air. When the aqueduct is partly close and partly open, or if, when close, it cannot withstand the whole pressure when the demand ceases, either a system of weirs is required to discharge the surplus water, or a second store-reservoir is provided, resembling in general plan and construction the impounding reservoir.

The distributing conduits also consist of cast-iron pipes, and are coated, like the aqueduct pipes, with pitch, or Dr. Angus Smith's varnish, to preserve them from corrosion. The magnetic oxide of iron produced on the surface of the metal by Barff s process answers the same purpose and is coming into use. Pipes should have turned and bored joints, and not be calked with tow or gaskin next the interior of the pipes. The same details with regard to sluice-cocks and stop-cocks are observed in the different bends of the tracks, with this addition, that the dead ends or terminations of the branch and main conduits are supplied with scouring valves, through which stones and sediment can be washed. In wide streets, or in streets with much traffic, there is generally a service-pipe for each side, in order that the house-pipes may be as short as possible, and may be accessible without disturbing the traffic. The house service-pipes are usually made of lead, and though they are liable to be acted upon by some waters, the readines with which they can be adapted to all the bends and curves rendered necessary in carrying the piping to different floors of houses, gives them a preference to all other kinds of metal pipes. The waters which act most on lead are the most highly oxygenated, and those which contain organic matter, nitrites, nitrates, and chlorides; those which act least on it contain salts of lime and magnesia, or they coat the metal with sulphate, or basic carbonate, of lead. When

silica is present even in minute traces the action on lead is very slight. The waters of Sheffield and Huddersfield, which act strongly on new lead, have been rendered comparatively inactive by passing them through rough filters of sand, broken flints, and pieces of limestone. Polluted shallow well waters are especially dangerous, because they act on lead violently and continuously, and hence leaden pump-pipes should never be used. Various means have been proposed to protect the lead from corrosion, such as coating with bituminous pitch or with coal-tar; but when the quality of the water renders lead pipes objectionable, cast and wrought iron pipes make the best substitutes, or composite cylinder pipes. These pipes consist of a separate tube of pure block-tin encased in lead, and the union of the two is so perfect that no amount of torsion will separate them. All the leaden service-pipes of a house should be strong (12 lbs. per lineal yard for one-inch pipes, and 6 lbs. per yard for half-inch pipes), to withstand pressure.

As the greatest hourly demand for water is about double the average hourly demand, the main conduits supplying a town must have double the discharging capacity which would be required if the hourly demand were uniform. The additional expense in piping which would be thus entailed is sometimes so great that distributing basins or town-reservoirs are constructed to supply certain districts. To meet all emergencies, they are made large enough to contain at least a day's supply, and they must also have a site of sufficient elevation to ensure distribution by hydrostatic pressure. Every such reservoir should be roofed in and ventilated, to protect the water from frost and heat, and from becoming tainted with aerial impurities.

4. *Constant and Intermittent Systems of Water-supply.*—The water thus distributed to the various houses in a district is supplied either on the intermittent or the con-

stant system. The intermittent system necessitates storage in house-cisterns, and is attended by so many disadvantages that the constant system should always be adopted wherever it can be carried out. The use of cisterns, except on a small scale for water-closets and boilers, is open to the great objection of the risk of contamination of the water, for not only are the cisterns liable to become fouled if not sufficiently protected against the entrance of aerial impurities, but the water always becomes flat and insipid, and is apt to become tainted with sewer-gases. Moreover, in poorer districts, the cisterns are often of a very inferior description, are badly situated, and are seldom inspected or cleaned out. To meet this objection it has been proposed to have one large tank for the supply of a group of houses,—the tank to be under the immediate inspection of the waterworks' officials, and to be filled daily, and the householders to be supplied through small pipes constantly charged. It is further urged against the intermittent system that the distribution pipes, being alternately wet and dry, are liable to collect dust and the effluvia from sewers, or drains, or neighbouring gas mains. The objections to the constant system, on the other hand, are the great waste when the fittings are imperfect, and an insufficient delivery when the water-supply is not abundant. The diameters of the pipes for constant service should therefore be carefully adapted to their discharges and to the head of pressure; the drawing taps ought to be valve-cocks to open and shut with a screw; and the town should be efficiently provided with distributing basins, so that an extra flow of water in one district would not interfere with the requisite supply of other parts. In large towns where some parts are much lower than others, care has to be taken that the mains and branches in the lower parts are not exposed to excessive pressure, and this is obviated by causing "loss of

head" either by passing the water through small inlets or by the use of loaded valves. With proper fittings, strict regulations, and efficient supervision, it is now clearly established that a constant supply requires a less amount of water than an uncontrolled intermittent supply, so that even on the score of economy the constant system is to be preferred.

In order to prevent undue waste, water-meters are sometimes applied to the service-pipe supplying a group of houses, and the landlord charged for the amount used; but as this plan induces the landlord to enforce a too rigid economy, it is not to be commended. The best water-meters are capable of registering exactly all amounts exceeding a flow of one gallon per hour; but when the water contains a considerable amount of undissolved impurities, and is badly filtered, they very soon become clogged up and fail to register anything like the quantity of water which may pass through them.

In order to detect waste, Deacon's meters are of great service. When these meters are placed on district mains they register the flow of water by day and night, and the amount found flowing through any particular main during the night, when there is no consumption, indicates the amount of waste. After localising the waste, the particular spots where the leakage occurs can be detected by auscultating the nearest house-pipes.

The waste-preventer, or small cistern for the supply of water-closets, which has already been alluded to, should hold 2 to 3 gallons, and in order to secure a good flush the service-pipe should be at least $1\frac{1}{4}$ inch in diameter.

Another plan for effecting economy in the constant system proposes that a cistern, large enough to hold a twenty-four hours' supply, be provided for each house, and that the service-pipe shall be of a diameter to deliver the required quantity during that time, and nothing more.

Every cistern supplied in this way would become gradually emptied during the daytime, and would be refilled during the night; but the plan is open to the great objection attaching to the intermittent system, and does not sufficiently provide for emergencies.

Wherever cisterns are employed for potable water they should be so situated that they can be readily cleaned out when necessary. The best materials for their construction are slate-slabs well set in cement, galvanised iron, or, better still, stoneware. Leaden cisterns, unless lined with a coating of pitch, tar, or other preservative substances, are objectionable, while wooden cisterns are liable to rot and harbour worms and decaying organic matter. All cisterns should be covered in, and protected from heat and frost. No cistern which supplies water for domestic use should be used to directly supply a water-closet; a waste-preventing cistern should always intervene. The inlet to every cistern ought to have a cock, with a float to rise and stop the supply when the cistern is full; and when the supply is constant, the overflow should be so arranged as to be seen if not immediately rectified. An overflow-pipe from a cistern should never lead directly into a soil-pipe, sewer, or drain, but should always discharge into the open. If this were always attended to, no sewer-gases could find their way to the cistern through this channel.

In addition to the arrangements for domestic supply outlets or hydrants with valve-cocks are provided on the service-pipes of all large towns, at regular intervals, in case of fire, and for supplying water to flush the gutters and water the streets.

In laying down water-pipes and mains, it is of great importance that the separation between them and sewers, drains, or gas-pipes should be as wide as possible. Whether the water-supply be on the constant or intermittent sys-

tem, the risk of suction of gases or fluids into leaky mains is imminent, though of course much less when the supply is constant. Unfortunately, however, this danger of contaminating public water-supplies has hitherto not been appreciated, and indeed in many towns it has been enhanced by arrangements for flushing sewers directly from the mains.—(See Simon's *Reports*, New Series, No. VII.)

Another danger to a public water-supply is the direct connection of water-mains with closet-pans. In Warwick and Rugby I found that nearly one-fourth of the closets were flushed directly from the main by means of stool-cocks, and on my recommendation the whole of them were disconnected. As a consequence of this precautionary measure, although the water-supply was made intermittent in Warwick during three months for the last three years owing to scanty supply, the town continued entirely free from enteric fever, nor was there any excess of diarrhœa.

Section IV.—Purification of Water.

On an extensive scale the process of purification is carried on by means of filtration, the water being received into large filter-beds previous to its distribution. A filter-bed may be described as a tank or reservoir several feet in depth, with paved bottom, on which are laid a series of open-jointed or perforated tubular drains leading into a central culvert. The drains are covered with a layer of gravel about 3 feet deep, over which is spread a layer of sand about 2 feet deep. The layer of gravel is coarse at the bottom, becoming gradually finer towards its upper surface, and the same relative gradation, as regards coarseness and fineness, is observed with regard to the sand. The water is delivered uniformly and slowly, and in order that the filtering process may not be carried on hurriedly,

the pressure is always kept low, the depth of water being seldom above 2 feet, and in some cases only 1 foot. The speed of vertical descent should not be much above 6 inches per hour, nor should the rate of filtration much exceed 700 gallons per square yard of filter-bed in the 24 hours, although some water companies filter at a much more rapid rate than this. In large works there are always several filter-beds, to allow of some being cleansed while the others are in use. The sediment deposited on the surface of the sand requires to be scraped off at intervals, and at each cleansing operation about half-an-inch of sand is also removed. A fresh supply of sand is added when the depth of the layer is reduced to an extent which threatens to impair the efficiency of the filter. It appears that proper filtration, carried on according to this plan, removes suspended impurities, and a certain amount of dissolved mineral substances, but whether dissolved organic matters are destroyed, or oxidised to any considerable extent, seems doubtful.

The magnetic carbide of iron has been used at Wakefield and other towns as a most valuable addition to the ordinary filtering media of sand and gravel in large filter-beds. It possesses considerable oxidising properties, and converts dissolved organic matters into nitrites and nitrates. Although the layers of sand on the surface of the filter-beds require frequent removal, the carbide need not be disturbed, but it is necessary that the process of filtration should be intermittent, in order to allow sufficient æration of the filter. Spongy iron, which is a porous metallic iron, possesses similar oxidising properties, but requires periodic renewal. It has been used on the large scale at Antwerp and other continental towns. Carferal, which is a mixture of iron, charcoal, and clay, has also been strongly recommended for use in large filter-beds, but this also requires renewal about once a year.

For domestic filters, animal charcoal was formerly the material most frequently used, but it is open to the objection that it yields to water phosphate of lime, which favours the growth of living organisms. It exerts a chemical as well as mechanical action on organic impurities, and at first acts rapidly and efficiently. After a time, however, it becomes inactive, especially with an impure water, and hence frequent renewal is necessary. Charcoal filter-cisterns should be abandoned altogether, because they are so situated that they are generally neglected, and they speedily become so foul that they contaminate the water which they are intended to purify. Animal charcoal can best be purified by bringing it to a red heat in an oven or furnace, or failing this, it should be boiled or washed in a solution of permanganate of potash and a little mineral acid; after which it should be exposed to the air and sun, again washed, and dried. The essentials of a good domestic filter are that all parts should be easily got at, so that the filtering medium can be cleaned or renewed; that the medium itself should be in sufficient bulk and possess sufficiently purifying properties; that it should yield nothing to the water; that it should not be liable to clog; and that it should filter with reasonable rapidity.

The filters which answer these requirements best are those in which spongy iron, magnetic carbide of iron, or carferal is used as the filtering medium. Of other filtering media silicated carbon and manganous carbon have also been highly recommended.

Among filters which have received special commendation may be mentioned the "Morris Circulating filter," which has the great merit of being easily cleaned, and so arranged that it can be used for charcoal, manganous carbon, or other filtering media. In Maignen's "Filtre Rapide" asbestos cloth and a substance called carbo-calcis

are employed as the filtering media. Bischoff's spongy iron filter, besides removing organic matter, lessens the hardness, and possesses the further advantage that it does not require æration because it should always contain sufficient water to cover the filtering medium. The substance requires renewal about once a year.

The "Chamberland" filter consists of porous earthenware cylinders through which water is passed under pressure. It acts mechanically by removing all suspended matter and bacterial organisms, and on this account is used to sterilise water for laboratory purposes.

Hard waters may be softened on the large scale by what is known as "Clark's process," by adding one ounce of quicklime per hundred gallons for every degree of temporary hardness. Spring waters in the chalk districts are all more or less "hard," and many of them contain such a large amount of calcic carbonate in solution as to be unfit for washing purposes. Such a water, when it is to be rendered "soft" by Clark's process, is let into a tank or reservoir, where it is mixed with a proper proportion of lime water and allowed to settle, the whole of the calcium being precipitated as calcic carbonate. A perfectly clear and wholesome water is thus obtained, well suited for domestic purposes. What is known as the "Porter-Clark process" is a modification of Clark's process, but instead of waiting for slow subsidence, the precipitated calcic carbonate is removed rapidly by filtration through cloth under pressure. This process of softening is founded on the fact that carbonate of lime, or chalk, is almost insoluble in waters which are free from carbonic acid, though soluble in those containing carbonic acid in excess. When, therefore, a solution of burnt lime is added to such a water in the exact proportion indicated by its hardness, the lime combines with the carbonic acid to form a carbonate

which falls down with the original carbonate,—the solvent power of the carbonic acid being withdrawn thus:—

$$CaCO^3 + CO^2 + CaH^2O^2 = 2CaCO^3 + H^2O$$

Water is softened by boiling, because the carbonic acid is driven off, and the calcic carbonate being no longer held in solution, is deposited as chalk.

Aluminous salts have long been used in Eastern countries to purify water, and are found to be very efficacious in removing suspended matters, whether organic or mineral. Suspicious waters should always be boiled before being used.

Among other purifying agents may be mentioned distillation, the exposure of water in minute divided currents to the air, the immersion of pieces of charcoal or of iron wire, and the effects of plants and fish. In store reservoirs, the presence of a moderate quantity of living plants exerts a decidedly purifying influence, while the destruction of fish has been followed by an excessive multiplication of the small crustacean animals on which the fish had lived, thereby rendering the water nauseous and impure. The remedy was found in re-stocking the reservoir with fish.—(*Rankine.*)

Section V.—Sources of Pollution.

Although reference has already been made in the preceding remarks to various ways in which drinking water becomes polluted, it will be expedient to consider this important part of the subject somewhat more fully in detail;—and first with regard to the water-supply of rural and small urban districts.

Cesspools, cesspits, or drains, in close proximity to wells, are a fruitful source of mischief; and so also are midden-heaps or deep ashpits connected with privies, and the huge manure-heaps which are allowed to accumulate in farmyards. All such collections of liquid or solid

filth should be regarded as dangerous nuisances, and should either be done away with altogether, or such adequate precautions taken as will obviate the risk of soakage into the well. The substitution of a dry system of conservancy and the use of pails or boxes for the cess-pool, common privy, and cesspit, together with better scavenging, would lessen to a very large extent the dangers of well-pollution in country districts; but in crowded localities the soil becomes so saturated with filth of all kinds that surface wells are never safe. All pump wells should be clay-puddled to a depth of eight or ten feet, to keep out surface impurities; and instead of draw wells or shallow open dip wells, which are especially liable to pollution, either proper pump wells should be provided, or, where the nature of the subsoil is suitable, tube wells would be found to possess many advantages. Surface wells near graveyards are very often found to be polluted.

But even when there is no drain or cesspool near, a well frequently becomes polluted because it is never cleaned out, and for my own part I regard this periodic cleansing of wells so necessary that I think every pump well should be provided with a manhole and be cleaned out at stated times. In towns or large villages provided with a public water-supply, the closing of all surface wells, whether public or private, should be rendered compulsory; for, with drains ramifying in every direction, it may be taken for granted that they are either polluted, or at all events constantly liable to pollution.

With regard to public supplies, it may be stated generally, that water may become polluted either at its source, in the course of distribution, or through defects connected with its storage. Any supply which is taken from a river polluted by the sewage of towns up-stream must be carefully filtered, and even then it can only be regarded as a suspicious water. Deep wells or springs,

on the other hand, may become polluted by the entrance of surface impurities, or by the access of polluted water through open fissures in the rock. But perhaps the most frequent and insidious sources of pollution to which public supplies are exposed are those dependent upon the arrangements for distribution and storage. It has already been pointed out that, with an intermittent supply, the mains must necessarily become full of air when the water is turned off, and if at all leaky, as they very often are, they may become charged with liquid as well as aerial impurities. Moreover, when water-closets are served direct from the mains by mere taps or stop-cocks, there is always the danger of liquid filth being sucked into them whenever a closet-pipe becomes choked up, and the pan becomes full. The following experiment will illustrate how readily such pollution may occur :—In the report on Croydon, already referred to, Dr. Buchanan states that he had a common house tap connected with a pan containing solution of burnt sugar sufficient to colour some thousand gallons of water, and that in the ordinary night-intermission of supply, the whole of this was straightway sucked into the pipes, and except from one neighbour, was no more heard of. He also adds that there is an instance on record of bloody water coming from the main tap of a house situated next to a slaughter-house. Then, too, connected with this system of intermittent supply, there are all the risks of contamination attaching to cisternage, or storage in pails, butts, or other receptacles. If the same cistern is used to supply the house and the water-closet as well, sewer-gases from the closet have access to the surface of the water in the cistern; or should the overflow-pipe from the house cistern discharge direct into a sewer or drain, there is of course the same danger. Apart also from the risk of lead-pollution from leaden cisterns, the water stored

in a cistern may eventually become unfit for use, because the cistern is seldom or never cleaned out.

But even with a constant supply there appear to be certain dangers depending upon possible in-currents from leaky mains, especially when these are in juxtaposition to sewers or drains which have hitherto escaped the notice of engineers. The physical conditions under which such in-currents may take place have been investigated to a certain extent by Dr. Buchanan, and I quote his results here, in order that others may be induced to make experiments in the same direction. In a note appended to the Croydon report he gives the following summary of results :—"I find (1) the lateral in-current is freely produced when the water-pipe is descending, and when the pipe beyond the hole is unobstructed; (2) if the force of water-flow in a descending pipe be moderate, a moderate degree of obstruction beyond the hole does not prevent the in-current; (3) in horizontal pipes of uniform calibre, when the flow is strong, or the pipe beyond the hole is long, or when the end of the pipe is at all turned upwards, the in-current does not take place, but (4) momentary interference with flow *a tergo*, or momentary reduction of obstruction *a fronte*, allows of a momentary in-current through the hole; (5) in-current through a lateral hole takes place with incomparably greater ease when the hole is made at a point of constriction of the water-pipe."

It has further to be observed that water mains, if not sufficiently protected against corrosion, may render the water turbid, owing to rusting of the iron; that the tow or gaskin employed to caulk joints may taint the water for a long period if the main is several miles in length; and that leaden pipes, especially when first laid down, may become a source of danger if the water is soft, or contain vegetable acids.

CHAPTER VIII

WATER ANALYSIS

Section I.—Collection of Samples.

In collecting water for analytical purposes, and particularly when it is intended to submit samples to a quantitative analysis, the following directions should be observed :—An ordinary glass-stoppered Winchester quart bottle will answer very well for the conveyance of the water. It should be cleaned out with strong sulphuric acid, then rinsed with ordinary good water until the rinsings are no longer acid, and finally washed out with some of the water to be examined. The bottle should be filled almost up to the neck, stoppered, and the stopper covered over with a piece of clean calico, wash leather, or gutta-percha tissue, tied, and sealed. No luting should be used except sealing-wax, and even that should be dispensed with if possible. If the water contains organic matter, it should be examined at least within forty-eight hours after being collected.

In collecting pond or lake water the bottle should be plunged into the water as far as possible from the bank, with the mouth well under the surface, so as to avoid the scum, care being taken, at the same time, that the mud at the bottom is not disturbed. If the sample is taken from a town supply, it should, if possible, be collected direct from the mains, or from the water-jets at the cab-

stands or public fountains, in which case the water should be allowed to flow for some time previous to filling the bottle. If taken from a house-service tap, the water should also be allowed to flow for some time before collecting. With regard to river water, it is recommended to select the middle of the stream, to avoid the outlets of sewers and feeders, and to note whether there has been previously a heavy fall of rain or a long drought. When a sample is required from the source of a spring, it is sometimes necessary to dig a small excavation and allow all sediment to subside before the sample is taken. Well-water should of course be drawn direct from the well.

Different methods of examination require different quantities; for Mr. Wanklyn's method one Winchester quart will be quite sufficient, but for a complete investigation some analysts require about a gallon. If a Winchester quart cannot readily be procured, a clear glass wine bottle will answer very well, but care must be taken to have it thoroughly clean, and the cork should be clean and new, and fit well.

The medical officer of health will find it very convenient to have a basket containing two or more clear glass-stoppered bottles placed under the charge of the sanitary inspector of the district. The basket should be provided with a padlock fitted with two keys, one of which should be in the possession of the medical officer of health and the other retained by the inspector. Before forwarding the bottles, the inspector should affix a label to each, containing the date and a distinctive number, or certain particulars with regard to the source of the water and why it is suspected. For ordinary analysis pint stoppered bottles will be found to be large enough, because, should a greater quantity be required at any time, two bottles can be used instead of one.

Section II.—Physical Examination.

A portion of the sample collected should be poured, after shaking the bottle, into a good-sized clear glass flask. If the flask is then held in front of a dark-coloured surface, with a good light falling on the side or from above, any suspended impurities will become visible, but care should be taken to discriminate between them and air-bubbles.

Colour and turbidity are best ascertained by pouring the water into a two-foot tube of colourless glass, and placing it upon a porcelain slab or piece of white paper. Another glass of the same dimensions, filled with distilled water, should be placed by its side for comparison. Both samples are then looked through from above, and the difference between them noted. If organic matter is present, the water has usually a tinge of yellow, green, or blue, but mineral substances may give similar indications. Clay, peat, and vegetable contaminations impart a brownish tint.

To observe the smell of the water, a portion of it should be poured into a wide-mouthed flask, making it about one-third full, and then shaking it well. If the smell is unpleasant, the water is unfit to drink. Should no smell be detected, the flask should be heated, and the water again shaken, and if there is still no smell a little caustic potash should be added to the warm water. Any unpleasant odour which may now be given off indicates with tolerable certainty that the water contains organic impurities in considerable quantity. The occurrence of a precipitate on the addition of the caustic potash will at the same time indicate hardness.

Many waters from the clay or lias formations yield distinctly offensive odours owing to the presence of sulphuretted hydrogen, which is given off by the mineral

sulphides, such as pyrites, or results from the decomposition of sulphates by organic matter.

A water which is evidently turbid, and which possesses an offensive odour and unpleasant taste, requires no detailed analysis to condemn it;—such a water may at once be pronounced as unfit for domestic use.

Section III.—Microscopical and Biological Examination.

In order to collect the sediment the water should be poured into a large depositing-glass, and allowed to stand for twelve or twenty-four hours. The sediment which collects at the bottom can then be removed by a pipette, and drops can be placed under the microscope without any preparation, while others can be distributed on slides for more extended examination. Some may be dried and examined for bacteria by staining with methyl violet, while by colouring others with carmine and glycerine, any cells may be detected by the red staining of their nuclei which results.

Particles of sand are recognised by their angular shapes and by their not being affected by acids. Particles of clay and marl are amorphous, and are also unaffected by acids. Particles of chalk are amorphous, and are readily dissolved by acids. Dead vegetable matter, such as woody fibre and portions of leaves, and living vegetable matter, consisting of confervoid growths, may all be detected in water, which cannot be pronounced unwholesome. So also may *diatomaceæ, oscillatoriæ, volvocina,* and *entomostraca.* Dead animal matters, such as hairs, striped muscular fibre, and epithelium scales; and manufactured matters, such as fibres of cotton, wool, linen, or silk, are all indicative of pollution of the water with human refuse, and most probably with sewage. Associ-

ated with these matters and feeding on them will generally be found *bacteria*, and other micro-organisms, such as *infusoria* and *amœbæ*; and indeed it may be said generally that the presence of these lowest organisms should always be regarded with suspicion. Microscopical examination, however, is only valuable in so far as it reveals the various kinds of suspended matters and the indications to which they point; it gives no direct information concerning the presence of organic impurities.

Nor can it yet be said that much practical value has resulted from the biological examination of waters. Although various methods are followed in conducting this examination, they all of course depend on the cultivation of the micro-organisms which may be present in the water in carefully sterilised nutrient gelatine. A ready method is to take a measured quantity of the water, say ·5 or 1 c.c., mix this in a test-tube with nutrient gelatine, and pour over a glass plate, which should be placed under a bell-jar with suitable precautions to exclude the entrance of atmospheric impurities. After a few days the micro-organisms or spores develop into colonies which may be counted, and under the microscope they may be differentiated as bacteria, moulds, fungi, etc., while subcultures of these colonies may be made if deemed desirable.

Section IV.—Chemical Examination.

This may be either qualitative or quantitative. For ordinary purposes, as, for example, in the discharge of a medical officer of health's duties in rural districts, a qualitative examination, if judiciously conducted, will be found to be quite sufficient to enable him to give a reliable opinion as to whether a water is fit for use or not in a great many instances, provided the water is not specifically polluted. But in all cases in which qualita-

tive tests indicate that a water is doubtful or suspicious, and in cases which are likely to lead to magisterial proceedings, it is necessary to submit the sample to a quantitative analysis more or less complete. A quantitative analysis is also required in the examination of public supplies, and in the case of any proposed new public supply it should be thorough in all its details.

In making a detailed qualitative analysis, it is advisable to concentrate a portion of the water to be examined to one-fiftieth of its bulk in a porcelain dish, otherwise important ingredients, such as lead, magnesium, or phosphates, might be overlooked. Nearly all waters are more or less alkaline, and therefore yield a yellow colour with methyl orange, and a dark red with cochineal. If acid, methyl orange yields a reddish, and cochineal a yellow tint. Litmus and turmeric papers may be used instead, but are not such delicate tests. If acidity disappears on boiling, it is due to carbonic acid; if alkalinity is permanent it is due to sodium carbonate.

But the main object which the sanitarian has in view is to determine whether or not any given water is dangerously contaminated with organic matter, and this, as I have already said, may be ascertained in the great majority of instances by a qualitative examination. After noting the various indications obtained from the physical examination previously described, and taking care that all test-tubes, test-glasses, measures, and the like are thoroughly clean and conveniently arranged, the qualitative testing of one or more samples may be readily conducted as follows:—

1. *Qualitative Examination.*

(1.) *Ammonia.*—Fill an ordinary test-tube of about 1 oz. in capacity nearly full with the water to be

examined, and then add a few drops of the Nessler re-agent. If a yellow or brown colour, or a brownish precipitate, be produced, the water contains ammoniacal salts. As a rule, this should be regarded as a very suspicious circumstance, and should the coloration be well marked, it is almost sufficient of itself to condemn the water for drinking purposes. A milky or curdy-looking precipitate will also indicate that the water is hard. If the precipitate is excessive, it masks, to a certain extent, the colour indicative of the test, in which case it is advisable to take a fresh sample in another test-tube, add a few drops of a strong solution of caustic potash, and after the precipitate which is thus formed subsides, add the Nessler re-agent.

(2.) *Nitrites.*—Fill an average-sized test-glass about three parts full of the water to be examined, then add 5 minims of pure sulphuric acid and 5 minims of a solution of potassium iodide (5 grains to 1 oz. distilled water), and afterwards pour in a small quantity of freshly-prepared starch solution. The solution is best prepared by rubbing one part of starch with 20 parts of boiling water. The liquid is then filtered, boiled, and, after being allowed to stand for twenty-four hours, the clear liquid is syphoned off. A blue tint indicates nitrites, and should the colour be at all deep the water is scarcely fit to drink. As iodide of potassium sometimes contains iodate, it is always advisable to make a comparative experiment either with distilled water or with a water which is known not to contain nitrites. Instead of the sulphuric acid, acetic acid may be used, and the starch paste, potassium iodide, and acid may be mixed before adding the solution to the water.

The meta-phenylene diamine test is still more delicate, but it takes twenty minutes before the full development of colouring is reached. The solution is made by dis-

solving 5 grammes of meta-phenylene diamine in 100 c.c. of water, and slightly acidifying with sulphuric acid. 1 c.c. of the re-agent added to 50 c.c. of the water yields a pale yellow tint, increasing to a deep orange red according to the quantity of nitrites present.

(3.) *Nitrates.*—A ready method of testing for nitrates is that known as Horsley's test, of which the following modification has been proposed by Dr. Bond of Gloucester: Put 20 minims of pure sulphuric acid into a very small test-tube, then add 10 minims of the water to be examined, and afterwards drop in carefully 1 drop of a solution of pyro-gallic acid (10 grains to 1 oz. distilled water acidulated with 2 drops of sulphuric acid). A pink zone, or sometimes a delicate blue zone changing into a dark amethyst tint, and from that into a brown tint, indicates nitrates. When shaken up, the greater part of this coloration may disappear for a time, but it gradually returns, and after the mixture has stood for a few hours a permanent tint is developed.

Another test for nitrates is that known as the brucine test. The solution of brucine is made by dissolving 1 gramme of brucine in 1 litre distilled water. An equal portion of this should be mixed with the water to be examined in a test-glass, and pure sulphuric acid should be poured gently down to form a layer at the bottom, when, if nitric acid be present, a marked pink and yellow zone is developed.

The process of nitrification by which nitrogenous matter in water or in the soil is oxidised with formation of nitrates is due in great measure to the action of microbes. Nitrites, as a rule, indicate more recent pollution than can be inferred from the presence of nitrates. Indeed, the detection of nitrates in a water derived from a deep well is no evidence of sewage contamination, because, as in the chalk formation, they

may be derived from the strata through which the water passes, but in surface or shallow well waters their presence may fairly be regarded as a suspicious circumstance.

(4.) *Chlorides.*—The amount of chlorine in water can be determined so quickly by a simple volumetric method, which will be subsequently described, that those who are provided with the test-solution of nitrate of silver should always adopt this method; but to those who have not this test-solution the following method is recommended: Acidulate a little of the water in a test-glass with a few drops of dilute nitric acid, and add in excess a solution of nitrate of silver. Four grains per gallon of sodium chloride give a turbidity; 10 grains a slight precipitate; and 20 grains a considerable precipitate, soluble in ammonia. A good water should only yield a slight haziness. If there is a distinct precipitate, it shows that the water is derived from a formation rich in salt, such as the new red sandstone, that it is brackish if on the sea-coast, or that it has been contaminated with sewage. In the first two cases there will be a large amount of mineral solids, and therefore, in the case of a soft water, any excess of chlorides would point to sewage contamination, especially if the precipitate is of a dark colour.

(5.) *Phosphates.*—Acidulate a portion of the concentrated water with nitric acid, and add double the quantity of a solution of ammonium molybdate. If phosphates are present a well-marked yellow colour is developed, and on standing, a precipitate.

(6.) *Sulphates.*—Acidulate with a few drops of hydrochloric acid, and add a solution of barium chloride. One-and-a-half grains per gallon will yield no haziness until after standing, but 3 grains will yield an immediate haze.

(7.) *Sulphides.*—Add a few drops of dilute hydrochloric acid, when hydrogen sulphide is evolved which can be detected by its odour, or if moist acetate of lead

paper is held over the mouth of the tube it will turn black. If a solution of sodium nitro-prusside is added, a violet purple colour indicates that the sulphides are alkaline.

(8.) *Lime.*—Add a solution of ammonium oxalate. Six grains per gallon will yield a turbidity; 16 grains a distinct precipitate; and 30 grains a large precipitate soluble in nitric acid.

(9.) *Magnesia.*—Filter water after addition of ammonium oxalate to remove lime, then add a few drops of sodium phosphate solution, ammonium chloride solution, and excess of pure ammonia. In twenty-four hours a precipitate of the triple phosphate forms either in the shape of prisms or in feathery crystals.

(10.) *Iron.*—Add solution of ammonium sulphide. A black colour or precipitate disappearing on addition of dilute acid will indicate the presence of iron. A mixture of potassium-ferro and ferri-cyanide strikes a blue colour.

(11.) *Lead.*—Ammonium sulphide yields a black colour not removable by hydrochloric acid. A solution of cochineal strikes a slight red colour with bluish tinge, merging into a deep blue mauve according to the amount of lead present.

(12.) *Copper.*—Copper yields the same reactions as lead with ammonium sulphide, but may be distinguished from lead by the ferro-cyanide test, which when added to a water with a trace of copper yields a brown colour, or if more be present, a brownish precipitate.

(13.) *Zinc.*—Although copper is rarely present in water, zinc is readily dissolved from galvanised iron water-pipes, which are sometimes used for small supplies. Potassium ferro-cyanide added to a filtered and acidulated water containing zinc yields a white haziness or heavy precipitate, according to the amount present.

(14.) *Organic matter.*—In the absence of iron, nitrites,

and sulphides, a solution of potassium permanganate will give indications of the presence of organic matter, but the test is not very reliable. Rapid decoloration would point to the presence of organic impurities of animal origin, while slower decoloration would indicate the presence of vegetable impurities.

If the medical officer of health is well acquainted with the geological characteristics of the well-waters in his district, a very few of these tests, such as the tests for free ammonia, nitrites, and chlorides, together with the indications given by the physical appearances, will enable him in a great many instances to give a reliable opinion, and he can examine several samples in a comparatively short space of time; but, in order to conduct the examination systematically, he ought to arrange the test-tubes or glasses in separate sets, and number them according to the samples. These, it is presumed, are all derived from surface or shallow well-waters, and the following indications will enable him to decide as to whether the water is fit for use or not, or whether it is of doubtful purity, in which case it should be submitted to a quantitative analysis:—

If the water contains a considerable amount of sediment, and is found when decanted off or filtered to show little or no traces of ammonia, nitrites, or chlorides, it shows that it is fit for use, but the well requires cleaning out; or, should the well be a tube well, that it ought to be filtered. If the sediment is flocculent and dirty-looking, it will generally be found that the water is polluted in other respects, and an order should be given that the well should be opened, examined, and cleaned out, and any ascertained source of pollution removed. In towns or villages where there is a public water-supply, and the premises are within easy reach of a water-main, there should be no hesitation in requiring the well to be closed;

or if the ground is so saturated with filth from leaky drains or cess-pits that it is hopeless to expect that any alterations can ensure subsequent safety, an order to close the well should still be insisted on. But supposing the water is tolerably clear, or quite clear, what are the inferences to be drawn from the qualitative examination? If there is distinct coloration on the addition of the Nessler re-agent, but very little precipitate, and with no distinct indications of either nitrites, nitrates, or chlorides, it shows that the water is a soft water and fit for use, and that the ammonia is either derived from rain water or is probably of vegetable origin. If ammonia, nitrites, and chlorides in excess are all present, the water is polluted and unfit for use. A water with no great excess of chlorides, and which yields a large flocculent precipitate on the addition of the Nessler re-agent, but does not become tinted, and gives no indication of the presence of nitrites, nitrates, or organic matter, is a hard water, but otherwise may be fit for use. Should a water contain nitrates and traces of nitrites, but give no distinct indication of ammonia or chlorides, it may be considered fit for use. If nitrites and chlorides are both present in any excess, the water should be regarded as a very suspicious water, and be submitted to a more careful examination, even though the Nessler re-agent should produce no distinct coloration. But it should always be remembered that chemical analysis, however complete, can only indicate danger when palpably present; it is powerless to indicate any standard of safety when a water becomes specifically polluted.

In giving instructions as to what action should be taken when a sample of well-water is found to be polluted, it is always advisable, when there is no public supply within reach, to recommend that the well should be opened and examined. The pollution may arise from

want of cleansing, or from leakage from a drain, cess-pool, or farmyard, and it will depend upon the special circumstances of the case as to whether cleansing and removal of the source of pollution will suffice, or whether the well should be closed altogether, and a new one sunk in some other suitable place where there is no risk of pollution. It is evident, therefore, that detailed information with regard to the situation and surroundings of a polluted well is of very material service in advising as to what particular steps should be taken; but, so far as the water itself is concerned, the medical officer of health need only report that it is contaminated and unfit for use. Should his recommendations, when notified in the regular way by the sanitary inspector, not be complied with, it may become necessary to submit the water in question to a quantitative analysis, in order to obtain a magistrate's order to cleanse, repair, or close the well, as the case may be.

2. *Quantitative Analysis.*

With the exception of proposed new public supplies, which should in all cases be submitted to a very minute analysis, the only points which require determination in an ordinary quantitative analysis are the total solids, the hardness, the chlorides, and the organic matter as represented by the free and albuminoid ammonia. If deemed necessary, additional evidence as regards the quality of a water will be obtained by determining the amount of oxygen absorbed, the amount of nitrogen existing as nitrates and nitrites, and, qualitatively, the amount of phosphates.

(1.) *Total Solids.*—The amount of total solids is ascertained by evaporating a known portion of the water to be examined to dryness. Into a platinum dish which has been carefully cleaned, dried, and weighed, pour 70

c.c. of the sample of water; place the dish over a ring burner, and evaporate down to a small quantity, taking care that there is no simmering or boiling, then evaporate to dryness in a water-bath, wipe the dish externally, and weigh. The difference between the two weighings gives the weight of the residue yielded by 70 c.c. of water. Seventy c.c. are taken because each milligramme of residue counts for one grain of total residue in a gallon of water, inasmuch as a gallon of water weighs 70,000 grains, and 70 c.c. weigh 70,000 milligrammes.

If the operator has a very delicate balance, and has had some experience in chemical manipulation, 25 c.c. of the water to be examined will usually be found sufficient, provided the water contains an average amount of solids in solution; but in that case the result in milligrammes must be multiplied by 2·8 (4 × ·7) in order to obtain the total amount of residue in grains per gallon. Thus, to take the following example:—

Weight of dish . . .	24·286	grammes.
,, dish and residue .	24·295	,,
Therefore weight of residue =	·009	,,

But ·009 grammes are 9 milligrammes, and multiplying this number by 2·8 gives 25·2 grains as the amount of solid residue in a gallon of the water examined. If 100 c.c. are taken, the multiple will of course be ·7. The times occupied in the evaporation average about two hours for the 100 c.c., an hour and a quarter for the 70 c.c., and about half-an-hour when only 25 c.c. are evaporated. In drying the residue, the dish should be put into a hot-air bath, then allowed to cool, and weighed promptly afterwards to avoid deliquescence of the salts. As soft

waters yield a very insignificant residue, at least a quarter of a litre would be required for evaporation.

The total solid residue consists for the most part of mineral matter, and in many waters this is composed chiefly of carbonate of lime. It is difficult to fix the maximum amount of permissible solid residue in drinking water. In public supplies it certainly ought not, if possible, to exceed 30 grains per gallon, but many usable well-waters are found to contain double this amount.

The following are examples of the amount of solids in different waters:—

	Grains per Gallon.
Loch Katrine	2·30
Bala Lake	3·18
London Thames Companies	21·66
Rochdale spring	25·93
Norwich artesian well	26·70

If a complete quantitative analysis of the saline constituents is required, a much larger quantity of water must be evaporated, but the presence and relative amount of the more important constituents may be approximately determined by some of the qualitative tests just described.

It is seldom, however, that these subsidiary tests are required. A more important indication is obtained by incinerating the residue over a flame, when, if blackening occurs, the presence of organic impurities may be inferred, and should a bad smell be given off at the same time, it is almost certain to be derived from impurities of animal origin. The dish may be again cooled and weighed, when the loss of weight is returned as loss on ignition, and the final residue may be used for the qualitative determination of phosphates when that is deemed necessary.

(2.) *Hardness.*—It has already been pointed out that a water is hard or soft according to the amount of solid residue which it contains. Thus a water which contains only 3 to 4 grains of residue, such as the Loch

Katrine water, is an exceedingly soft water; a water containing 8 to 10 grains is a moderately soft water; while those which contain 20 grains and upwards are hard waters. For purely sanitary purposes, therefore, the determination of the hardness is seldom required, if the total solid residue has been ascertained. The hardness of a water is due to the presence of earthy salts, generally carbonate of lime and sulphate of lime and magnesia. The former is deposited on boiling, and is represented by what is called the removable hardness, while the latter, inasmuch as it is not affected by boiling, is called the permanent hardness. The *rationale* of the process, as first explained by the late Professor Clark, will be understood when it is remembered that if an alkaline oleate, such as soap, is mixed with pure water, a lather is formed almost immediately; but if salts of lime, magnesia, baryta, iron, or alumina are present, oleates of these bases are formed, and no lather is given until the earthy bases are thrown down. As the soap will combine in equivalent proportions with these bases, it is only necessary to make the solution of soap of known strength by standardising it with a known quantity, say of chloride of calcium, to be able to determine the amount of lime or its equivalent of other salts in the water—so much soap required before a lather is produced represents so many degrees of hardness. The standard solutions are prepared and determined according to the following method, proposed by Messrs. Wanklyn and Chapman: Make a solution of pure calcium chloride of 1·110 grammes to the litre of distilled water, or preferably weigh 1·0 gramme of commercial precipitated calcium carbonate dried at 300° Fahr., dissolve in slight excess of pure hydrochloric acid, evaporate to dryness, and make up to litre with distilled water. Each c.c. of either solution is equivalent to one milligramme of carbonate of lime. The standard

soap test is made by pounding together two parts of lead plaister with one of carbonate of potash, exhausting repeatedly with alcohol at 90 per cent, and using about thirty times as much alcohol as lead plaister. This solution is allowed to stand for some time, and is then filtered, and afterwards diluted with its own volume of water. In order to standardise it, 10 c.c. are taken and put into a bottle with 70 c.c. of pure water; the chloride of calcium solution is now added until frothing stops, care being taken to shake properly; and from this trial experiment it is easy to calculate how much dilution of the soap solution is requisite in order to make 17 c.c. of the soap test use up 16 c.c. of the chloride of calcium solution. The dilution should be made with alcohol of 50 per cent, and the soap test carefully verified after it has been made up. This is done by adding 16 c.c. of the standard solution of calcium chloride to 54 c.c. of distilled water, thus making a solution of 70 c.c., which should exactly be neutralised by 17 c.c. of the standard soap test.

A much easier method of making the soap test, and one which gives fairly accurate results, is to dissolve 10 grammes of green Castile soap in a litre of weak alcohol of about 35 per cent. One c.c. of this solution also precipitates one milligramme of carbonate of lime. Either solution, therefore, may be used, and the mode of employing the test is as follows:—

Into a clear glass-stoppered bottle, capable of holding about 250 c.c. put 70 c.c. of the water. Add slowly from a burette the standard soap solution, and shake well until a persistent lather is formed, when the bottle is laid on its side noting accurately the amount of solution used. Each c.c. of the solution consumed indicates 1 grain of carbonate of lime or its equivalent in a gallon of water. If, after adding 17 c.c. of the solution, no lather

is formed, add 70 c.c. of distilled water and mix, and continue the addition of the soap solution. Should no lather be formed until other 17 c.c. are consumed, other 70 c.c. of distilled water must be added, but in making the calculation for hardness 1 must be deducted from the number of c.c. of soap solution used for each 70 c.c. of water which have been added, and this deduction is necessary because 70 c.c. of distilled water would themselves neutralise about 1 c.c. of soap test. Suppose, for example, that 18 c.c. of soap solution have been required, then 1 must be deducted from the 70 c.c. of distilled water which were added, and the hardness of the sample in question is put down as 17 degrees. In other words, the total soap-destroying powder of the water is equivalent to 17 grains of carbonate of lime per gallon. The permanent hardness is obtained by boiling 70 c.c. of the water for about an hour, and making up the loss by evaporation with distilled water. During boiling, the bicarbonate of lime is decomposed and the carbonate deposited, and thus the water becomes softer. After allowing to cool and filtering, the permanent hardness is determined in the same way as the total hardness, and the difference between these two, as already stated, is the removable hardness.

According to Wanklyn's method, the degrees of hardness represent "the potential carbonate of lime," and in translating them into Clark's degrees it is necessary to deduct 1. Thus, in the above example, the degrees of hardness, according to Clark's standard, would be 16.

Altogether, the importance of this test has been greatly over-estimated, and it is seldom that the medical officer of health will deem it necessary to employ it.

(3.) *Chlorides.*—The estimation of chlorine as chlorides in water can be readily determined volumetrically by

means of chromate of potash and a standard solution of nitrate of silver. This solution is prepared by dissolving 4·79 grammes of dry nitrate of silver in a litre of distilled water. As chromate of silver is soluble in acids, it is necessary that the nitrate of silver used should be neutral. Each c.c. of this solution precipitates 1 milligramme of chlorine. Seventy c.c. of the water to be examined are put into a beaker or evaporating dish, and a small crystal of pure chromate of potash or a few drops of a strong solution of this salt added, sufficient in either case to produce a distinct yellow tint. The standard solution is then dropped carefully in from a graduated pipette or burette, and directly the first faint tinge of red is discernible and remains permanent on stirring, the whole of the chlorine is precipitated, and chromate of silver, which is a dark red, is formed. The number of c.c. of the solution used before this red tinge is obtained represents the number of grains of chlorine per gallon of water. If, for example, 3·5 c.c. of this solution have been required, the water contains 3·5 grains of chlorine per gallon.

The following are examples of the amount of chlorine in different waters:—

	Grains per Gallon.
Thames at Kew	·847
Thames at London Bridge . . .	4·452
Bala Lake	·706
Polluted well at Rugby . . .	7·5

The indications afforded by the chlorine test have previously been dwelt upon in the remarks on the qualitative examination of water, and they need not therefore be further referred to here.

(4.) *Ammonia and Organic Matter.*—Of the two rival methods of estimating the organic matter in water—namely, that of Frankland and Armstrong, and that devised by Wanklyn, Chapman, and Smith—there is a general concurrence of opinion that the latter is especially

suited for the medical officer of health, because it is easy of application, and, so far as chemical analysis can at present indicate, yields sufficiently accurate results for ordinary hygienic purposes. Frankland's process of estimating the organic carbon and nitrogen is a method of no small difficulty, and in the hands of any but an experienced chemist the risk of experimental error is very considerable. What is known as the *Ammonia process*, therefore, will be the process described here. For a full description of this process the reader is referred to Mr. Wanklyn's excellent text-book on water analysis, from which the following remarks are for the most part collated. The *rationale* of the process depends upon the fact that vague and indefinite nitrogenous bodies can be converted into a definite compound, namely, ammonia, and that in this way they can be estimated and expressed as ammonia. Owing to the excessive minuteness of the quantities of nitrogenous compounds which distinguish between a good and a bad water, it is convenient to adopt a much finer scale of measurement than is requisite for the saline constituents; and the amount of ammonia is accordingly expressed by milligrammes per litre, or so many parts in a million. The re-agents which are employed are the Nessler test, a standard solution of ammonia, a saturated solution of carbonate of soda, and a solution of potassium permanganate and caustic potash.

a. Nessler Test.—Dissolve, by heating, 35 grammes of iodide of potassium and 13 grammes of corrosive sublimate in about half a litre of distilled water, and afterwards add gradually a cold saturated solution of corrosive sublimate, and keep stirring until the red colour produced begins to be permanent. Then add 160 grammes of caustic potash dissolved in about 200 c.c. of distilled water, and dilute with sufficient water to bring the whole up to a litre. To render the test sensitive, add about 20

more c.c. of the saturated solution of corrosive sublimate, and allow it to stand in a stoppered bottle until the precipitate has subsided. The clear liquid may now be decanted and kept in a tightly stoppered stock bottle ready for use.

b. Standard Solution of Ammonia.—Dissolve 3·15 grammes of crystallised sal-ammoniac or ammonium chloride in one litre of distilled water. Every c.c. of this solution contains one milligramme of ammonia. This is termed the strong solution, and is the most convenient to keep. To prepare the dilute solution, put 5 c.c. of the strong solution into a half-litre flask, and fill up with distilled water. This is the standard solution of ammonia, and contains 0·01 milligramme of ammonia in 1 c.c. of water.

c. The Saturated Solution of Carbonate of Soda may be prepared by boiling an excess of the common carbonate in distilled water. About 10 c.c. of this solution is the proper quantity to use, or instead of the solution about 1 gramme of the dry carbonate of soda, which has just been ignited, may be employed. The carbonate of soda is used in order that the free ammonia may be more easily dispelled on distillation.

d. The Permanganate of Potash and Caustic Potash Solution is prepared as follows:—Dissolve 8 grammes of crystallised permanganate of potash and 200 grammes of solid caustic potash in one litre of distilled water. Boil the solution for some time to free it from all traces of ammonia, and afterwards replace the water lost by evaporation by adding sufficient distilled water to make up the litre.

The distilled water which is used to make up the various solutions may be obtained of sufficient purity from any common drinking water, if care is taken to reject the first portions of distillate, and the distillation is

not pushed too far. It should always be carefully tested before being used, and so chemically pure that in 100 c.c. there ought not to be 0·005 milligramme of ammonia.

The following is a list of the apparatus required for the process:—A stoppered retort, capable of holding at least one litre; a Liebig's condenser; a good-sized Bunsen's lamp or burner; a retort-holder; about half a dozen Nessler glasses made of white glass, and with a mark at 50 c.c.; a half-litre flask; a graduated burette marked into c.c., to measure off the standard solution of ammonia; and a pipette marked to hold 2 c.c. It need hardly be said that the greatest care must be taken to have the whole of the apparatus thoroughly clean before it is used. Glass vessels should first be washed out with a little strong hydrochloric or sulphuric acid, and afterwards with pure water.

The analysis itself is thus performed:—After mounting the retort on the holder, and properly connecting it with the Liebig's condenser, half a litre of the water to be examined is poured into it, and 10 c.c. of the solution of carbonate of soda added. The Bunsen lamp is now lighted, the retort thrust well down into the flame, and 50 c.c. are distilled over into a Nessler glass, and *Nesslerised.* Then distil over 150 c.c. and throw this distillate away. This amount is thrown away because it has been found that the first distillate contains exactly three-fourths of the free ammonia present in the water, and it is therefore a waste of labour to Nesslerise the whole of the four 50 c.c. distilled over. There are now 300 c.c. left in the retort, and in order to liberate the "albuminoid ammonia," 50 c.c. of the permanganate of potash and caustic potash solution are poured into the retort by means of a wide funnel. To prevent bumping, which is very liable to occur with a bad water, the retort should be gently shaken, so as to give the mixture a wavy motion.

The distillation is then continued, and three separate distillates, each of 50 c.c., taken and Nesslerised.

What is called Nesslerising is the process of ascertaining the strength of a dilute solution of ammonia by means of the Nessler re-agent, and is indeed one of the most beautiful examples of colorimetric analysis. Let the first distillate of 50 c.c. be taken as an illustration. To this distillate, which is contained in one of the Nessler glasses, 2 c.c. of the Nessler re-agent are added by means of the 2 c.c. pipette, which also serves as a convenient stirrer. If, after stirring and waiting about a couple of minutes, the liquid assumes a rich deep brown, it contains much ammonia; if even a distinct brown tint is developed, it contains a considerable quantity of ammonia; but if it remain colourless, it does not contain so much as ·005 milligramme. When only a light-yellowish tint is produced, the amount of ammonia present is comparatively small. In any case, however, the exact amount is determined by comparing with a known solution of ammonia. The depth of tint in the distillate is imitated by mixing, in a Nessler glass, more or less of the dilute standard of ammonia contained in the burette with distilled water, and filling up to 50 c.c., and then adding 2 c.c. of the Nessler re-agent. If, after stirring and waiting two or three minutes, the tint developed in the artificially prepared solution is too dark or too light, it is necessary to make another artificial solution of less or greater strength, as the case may be. With a little practice it is easy to approximate very closely to the exact amount of the standard solution of ammonia which will be required to produce a tint on the addition of 2 c.c. of the Nessler re-agent, which will harmonise completely with the tint of the distillate. In order to be able to compare the tints accurately, the Nessler glasses should be placed on a white porcelain slab or sheet of white paper.

The number of c.c. of the standard solution of ammonia, which on the addition of the Nessler re-agent were required to reproduce the exact tint given by the distillate, are noted, and the amount of "free ammonia" contained in the sample of water can then be readily calculated.

The other three distillates which contain the albuminoid ammonia are Nesslerised in the same way, and the amount of the standard solution of ammonia, which was required to imitate the tint in each case, is also noted. These several amounts added together represent the total "albuminoid ammonia" contained in half a litre of the water. It has already been pointed out that the first 50 c.c. which were distilled over contain three-fourths of the whole of the "free ammonia," and that therefore the next 150 c.c. distilled over may be thrown away. It was formerly the practice of Mr. Wanklyn to Nesslerise the whole four 50 c.c. to obtain the total of the free ammonia; but the amount contained in the first distillate was found to bear such a constant ratio to the amount contained in the other three distillates, namely, as 3 to 1, that it becomes a needless expenditure of labour to Nesslerise them. The rule, therefore, is to add one-third to the amount of ammonia found in the first distillate, in order to obtain the whole of the free ammonia.

Remembering now that each c.c. of the standard solution contains ·01 milligramme of ammonia, the calculation in any given case becomes very simple. For example, suppose the amount of dilute standard solution of ammonia required to match the tint in each case to be as follows:—

Free ammonia distillate		2 c.c.
Albuminoid ammonia	1st distillate	5 ,,
	2d ,,	2·5 ,,
	3d ,,	·5 ,,

then we arrive at the following amounts :—

		Milligrammes.
Free ammonia = $\cdot 02 + \frac{\cdot 02}{3} =$	. . . . .	·027
Albuminoid ammonia	1st distillate . . .	·05
	2d ,, . . .	·025
	3d ,, . . .	·005
	Total albuminoid ammonia . .	·08

But, inasmuch as half a litre of water was taken for analysis, these results must be multiplied by 2 in order to arrive at the amounts per litre, or per million parts. In the above example, therefore, the results would be stated as follows :—

	Parts in a Million, or Milligrammes per Litre.
Free ammonia = ...	·054
Albuminoid ammonia = . . .	·16

In this process of water analysis it will be observed from the above description that ammonia is to be looked for at two stages: firstly, in distilling off with the carbonate of soda solution; and secondly, on distilling off with the alkaline permanganate solution. The first portion of the ammonia is called the "free ammonia," because it is obtained from the decomposition of those organic impurities in water which are of simple constitution, such as the ureal class, as well as the ammonia which may be present as ammonia. The second portions of ammonia are named "albuminoid ammonia," because the ammonia which is given off is derived from the oxidation of those more complex nitrogenous impurities which are closely allied to albumen.

The following are examples of pure, indifferent, and bad samples of water, as determined by the ammonia process :—

	Free Ammonia, parts per 1,000,000.	Albuminoid Ammonia, parts per 1,000,000.	Quality.	Name of Authority.
Loch Katrine . .	·004	·08	Good	Wanklyn
Water from Kent Company's mains . .	·01	·02	,,	,,
Edinburgh Water Supply, Colinton, 1867 .	·14	·08	Indifferent	,,
Great St. Helen's pump, London . . .	3·75	·18	Bad	,,

With regard to the inferences which may be deduced concerning the quality of a water as indicated by this method of examination, Mr. Wanklyn has laid down the following rules in the third edition of his work on water analysis:—"If a water yield ·00 parts of albuminoid ammonia per million, it may be passed as organically pure, despite of much free ammonia and chlorides; and if, indeed, the albuminoid ammonia amount to ·02, or to less than ·05 parts per million, the water belongs to the class of very pure water. When the albuminoid ammonia amounts to ·05, then the proportion of free ammonia becomes an element in the calculation; and I should be inclined to regard with some suspicion a water yielding a considerable quantity of free ammonia, along with ·05 parts of albuminoid ammonia per million. Free ammonia, however, being absent or very small, a water should not be condemned unless the albuminoid ammonia reaches something like ·10 per million. Albuminoid ammonia above ·10 per million begins to be a very suspicious sign; and over ·15 ought to condemn a water absolutely."

But the experiments of Dr. Cory, to which reference is made at the close of this chapter, prove clearly that polluting matter, potent for harm, may be present in water which, according to Wanklyn's analysis, may be passed as organically pure, and hence it is of the utmost

importance that the surroundings and possible sources of pollution of a particular supply should always be carefully taken into consideration. No matter what process may be adopted, whether Wanklyn's, Frankland's, or Tidy's, water analysis can only indicate degrees of impurity and danger, not standards of purity and safety.

On the other hand, it must be admitted that there are many surface well-waters in country districts containing even more than ·15 parts per million of albuminoid ammonia, and to which no bad effects can be traced, but in these cases it is probable that the ammonia is chiefly derived from vegetable matter. If the quantity of chlorine found in a water is exceedingly small, any excess of albuminoid ammonia would indicate that the nitrogenous matter present is of vegetable and not of animal origin, and therefore comparatively innocuous. At the same time it should be remembered that there might be the same absence of chlorine if the water becomes polluted from the presence of the body of a dead animal in a well or cistern.

(5.) *Nitrogen existing as Nitrates and Nitrites.*—Several processes have been recommended for the estimation of the nitrogen existing in water as nitrates and nitrites, but the one most generally adopted is that known as the copper-zinc process. What is called the copper-zinc couple is best prepared as follows:—Take a piece of pure zinc foil about 2 inches wide and 4 inches long, cleanse thoroughly, then insert into a wide-mouthed stoppered bottle of 250 c.c. capacity, containing sufficient quantity of 3 per cent solution of cupric sulphate to cover the foil. Allow foil to remain in solution until there is a firm bronze-looking coating of copper deposited, then carefully pour off solution and thoroughly wash, first with pure water by refilling bottle, then empty and wash with the water to be analysed. Empty once more, and finally

refill with the water to be examined, add ·5 gramme of pure oxalic acid, and having inserted the stopper, allow it to remain either in the cold for twenty-four hours, or in a water-bath at from 130° to 140° Fahr. for two hours. The oxalic acid is added to expedite the process and to form insoluble salts of calcium and zinc. If the water does not contain any salts of magnesium, either 5 or 10 c.c. of the clear water may be drawn off with a pipette made up to 50 c.c., and Nesslerised at once in the usual way; but if magnesian salts are present it is necessary to draw off 50 c.c., make up to 250 c.c. with pure distilled water, rendered alkaline with pure caustic soda, and distilled until the last distillate of 50 c.c. is free from ammonia.

From the total amount of ammonia contained in the distillates deduct the quantity of ammonia which has been found to exist in the water as free ammonia, and calculate the amount of nitrogen represented by the difference between the two. For example, 70 c.c. of the water after treatment is distilled as above directed.

	Milligrammes of Ammonia.
1st distillate of 50 c.c. yields	·85
2d " " "	·08
3d " " "	·01
Total	·94

Now, suppose that the free ammonia found to exist in the water amounts to ·0098 milligramme in 70 c.c., then

$$\cdot 94 - \cdot 0098 = \underset{\text{Milligramme.}}{\cdot 9302}$$

In order to convert the ammonia into its equivalent of nitrogen the following will be the formula, where N represents nitrogen and NH_3 ammonia:—

$$\frac{NH_3 \times 14}{17} = N,$$

or, in this instance,

$$\frac{\cdot 9302 \times 14}{17} = \cdot 766 \text{ milligramme.}$$

But as 70 c.c. of the water were taken for estimating the nitrogen, the resulting milligrammes of nitrogen will represent grains per gallon, or ·766 grains per gallon.

With regard to the amount of nitrogen existing as nitrates and nitrites in different waters, the following data will be useful:—

	Grains per Gallon.
Spring water	·2
London Water Companies	·26
Some wells from the chalk	·6 to ·7

Any water not derived from the chalk formation containing more than ·7 grains of nitrogen per gallon would be regarded as suspicious, while if the amount reached 1·5 the water would be considered dangerous for drinking purposes.

(6.) *The Oxygen or Permanganate Process.*—The *rationale* of this process, which is known also as the Forschammer process, consists in estimating the quantity of oxidisable matter contained in a water by the amount of oxygen absorbed.

The re-agents required are:—

a. Permanganate Solution.—Dissolve ·395 gramme of pure potassium permanganate in 1 litre of distilled water. Each c.c. contains ·0001 gramme of available oxygen.

b. Potassium Iodide Solution.—Dissolve 1 part of pure potassium iodide in 10 parts of distilled water.

c. Dilute Sulphuric Acid.—One part by volume of pure sulphuric acid is mixed with 3 parts by volume of pure distilled water.

d. Sodium Hyposulphite.—One part of crystallised sodium hyposulphite dissolved in 1000 parts of water. This solution must always be standardised at the time of

using, and corrected so that 10 c.c. shall be equivalent to 10 c.c. of the permanganate solution.

e. *Starch* water.

The process is then conducted as follows:—

Select two securely stoppered bottles of about 500 c.c. capacity, and introduce into each 250 c.c. of the water to be examined, then add to each 10 c.c. of dilute sulphuric acid and 10 c.c. of standard permanganate solution discharged from a suitable burette. Insert the stoppers and place the bottles in a water-bath at 80° Fahr., and maintain that temperature for four hours. Two separate determinations are made, viz. the amount of oxygen absorbed at the end of fifteen minutes, and that absorbed during the whole four hours, each titration being conducted as follows:—At the end of fifteen minutes one bottle is removed from the water-bath, and a few drops of potassium iodide solution are added to remove the pink colour. After thoroughly mixing, the standard sodium hyposulphite solution is then run in until the yellow colour is nearly destroyed, after which a little starch water is added, and the titration continued until the water is colourless.

Example:—At the end of fifteen minutes from the time of adding the 10 c.c. of permanganate solution the bottle is removed from the water-bath, a few drops of potassium iodide solution added, and titrated with hyposulphite solution. Now, suppose that the amount required is 7·2 c.c., then,

10 c.c. − 7·2 c.c. = 2·8 c.c. of permanganate solution consumed by 250 c.c. of water,

∴ 2·8 c.c. × 4 = 11·2 c.c. of permanganate solution consumed by 1 litre of water; but

11·2 × ·0001 (co-efficient for oxygen) = ·00112 gramme or 1·12 milligramme of oxygen consumed by 1 litre in fifteen minutes,

= ·0784 grains of oxygen consumed by 1 gallon of the water in fifteen minutes at 80° Fahr.

At the end of four hours the contents of the other bottle are titrated in a similar manner, and the results expressed in the same way.

The inferences to be drawn from this process may be briefly stated as follows:—After four hours the amount of oxygen consumed should not exceed 1·0 milligramme per litre in a good water; if it exceeds this amount, and is under 1·5, the water is usable; but if this latter amount is exceeded the water is either suspicious or bad. It is also worthy of note that a bad or suspicious water is found to consume more than three times as much oxygen in the four hours as during fifteen minutes.

(7.) *Estimation of Phosphoric Acid.*—Take the residue which has been incinerated after weighing, moisten with strong nitric acid, and evaporate to dryness in a water-bath to render the silica insoluble. It is now again dissolved in dilute nitric acid, and passed through an exhausted filtered paper. If the filtrate exceeds 5 c.c. it should be concentrated by evaporation below this quantity. The filtrate is now tested quantitatively by the molybdic solution as follows:—Add to filtrate an equal volume of solution and warm gently. According to the depth or amount of decided precipitate phosphates are returned as "traces," "heavy traces," and "very heavy traces."

The molybdic solution is thus prepared: Molybdic acid, 1 part; ammonia sp. gr. ·960, 4 parts; nitric acid sp. gr. 1·2, 15 parts. The molybdic acid is dissolved in the ammonia, filtered, and poured with constant stirring into the nitric acid.

In conducting a water analysis it is expedient, if the amount of solids is to be taken, to commence the evaporation for the solids first, then to commence distilling for the ammonia, and while the evaporation and distillation are going on, to determine the amount of chlorides, and

the degree of hardness, if that be considered necessary. Afterwards, if deemed advisable, the nitrogen existing as nitrates and nitrites, the amount of oxygen consumed, and the phosphoric acid may be determined. It need hardly be said that a detailed record of the results of every analysis should be kept in a book set apart for that purpose. The form of report or certificate will of course vary according to the number of data and the mode of analysis, but the following hints will indicate generally how it should be drawn up :—

Date of reception of sample, size and description of bottle or bottles, how stoppered or sealed, and how labelled. From whom received.

Physical Examination.

Appearance .	(Clear, or slightly turbid, etc.)
Taste . .	(Tasteless, or unpleasant, etc.)
Odour . .	(Odourless, fœtid, etc.)
Deposit . .	(Slight or large, dirty-looking, flocculent, etc.)

Microscopic Examination.

(Sandy particles, vegetable matters, animal matters, vibriones, etc.)

Chemical Examination.

Qualitative results :—

Free ammonia .	(None—traces—large amount.)
Nitrites . .	(None—traces—large amount.)
Nitrates . .	(None—slight traces, etc.)
Sulphates . .	(None—slight traces, etc.)
Metals . .	(None—traces of lead, etc.)

Quantitative results :—

Total solids .	(In grains per gallon.)
Chlorides . .	(In grains per gallon.)
Free ammonia .	(Grains per gallon.)
Albuminoid ammonia	(Grains per gallon.)

Nitrogen existing as nitrates and nitrites	(Grains per gallon.)
Oxygen consumed by organic matter	(Grains per gallon.)
Phosphoric acid .	(Traces, heavy traces.)
Hardness, total .	(In degrees.)
,, permanent	(In degrees.)

Remarks as to whether the water is soft or hard, of good quality and fit for use, or whether it is polluted and unfit for use.

Date of analysis,—signature, etc.

As it has become customary to express the results in grains per gallon instead of parts per million, the following formula will indicate the method of calculation :—

100 : 7 : : ·15 (parts per million) : ·0105 (grains per gallon). (See Appendix.)

Exclusive of the microscopic examination, which is seldom undertaken, an ordinary water analysis giving the total solids, chlorine, and free and albuminoid ammonia may be completed in about an hour and a half, provided, of course, that the operator is fairly expert at his work, and has all his test and standard solutions prepared beforehand. The busy medical officer of health may obtain most of these solutions, as well as distilled water, from chemists, but he should always make blank experiments to test their purity and quality.

Although I have thus far endeavoured to describe clearly and concisely the various steps of an ordinary water analysis, I nevertheless consider it very essential that every one who has to undertake this kind of work should receive lessons in the laboratory of a competent analyst. If he is precluded from doing this, he may teach himself, provided that he has a sound knowledge of elementary and practical chemistry, but in this case he ought to experiment with samples obtained from a public supply, and compare his results with those of recorded analyses of that supply.

As already stated, any proposed new public supply should be submitted to a full quantitative analysis of its saline and other constituents, and for this purpose samples should be sent to a professed analyst. It should not only be usable, but the best which can be procured within the limits of reasonable expenditure. All waters subjected to filtration should be examined from time to time, to ascertain that the filtering process is carried on efficiently. Any water which gives indications of having become contaminated with animal or other impurities, and which has hitherto been good and wholesome, should be entirely disused until the source of contamination has been discovered and removed.

Concluding Remarks.—Although it must be admitted that the methods of water analysis which are now in use are capable of detecting very minute quantities of organic matter in large volumes of water, it must always be borne in mind, as previously pointed out, that chemical analysis, however complete, is powerless to indicate any standard of safety when a water becomes specifically polluted. The careful experiments conducted by Drs. Cory and Dupré, at the instigation of the Local Government Board, prove clearly that chemistry cannot tell whether a healthy or a diseased body has been the source of any excremental pollution of any particular water. Many of Dr. Cory's observations had special reference to experimental contamination of different waters,—some with healthy stools and some with the stools of enteric fever patients,—and the results not only gave no indication as to whether the polluting matter came from a healthy or diseased body, but failed to indicate the presence of an amount of specifically polluting matter which must have been far in excess of that which proved so disastrous in the well-known Caterham epidemic (see following Chapter). The lessons which may be learned from this inquiry are

so ably summed up by Dr. Buchanan, that I cannot do better than quote them here:—"While we must ever be on the watch for the indications that chemistry affords of contaminating matters gaining access to our waters, we must (at any rate until other methods of recognition are discovered) go beyond the laboratory for evidence of any drinking water being free from dangerous organic pollution. Unless the chemist is well acquainted with the origin and liabilities of the water he is examining, he is not justified in speaking of a water as 'safe' or 'wholesome,' if it contain any trace whatever of organic matter; hardly, indeed, even if it contain absolutely none of such matter appreciable by his very delicate methods. The chemist, in brief, can tell us of impurity and hazard, but not of purity and safety. For information about these we must go, with the aid of what the chemist has been able to teach us, in search of the conditions surrounding water sources and affecting water services."—(*Annual Report of the Medical Officer of the local Government Board*, 1881-1882.)

(8.) *Analysis of Sewage and Effluents.*—In analysing samples of sewage and effluents the same steps are followed as in water analysis, with the exception that as regards effluents it is advisable to estimate the matters in suspension. The estimation of the hardness is not necessary, and as nitrates and nitrites are speedily decomposed in sewage, the estimation of the nitrogen is obviously valueless. It need hardly be said that the character of any particular sample of sewage will vary very much according to the sanitary arrangements of the town, the nature and extent of manufactories, the amount of dilution by rainfall or subsoil water, the season of the year, the time of day at which the sample is collected, the amount of water-supply per head of the population, and other conditions; while the character of the effluent

will be further influenced by the particular process of purification adopted, whether by a chemical process, by filtration, by irrigation, or by a combination of these systems. Much, too, will depend upon whether any particular process is fairly and carefully carried out.

In making an analysis it will generally be found that 50 c.c. of sewage diluted to about 300 c.c. with distilled water will be quite sufficient for the estimation of the free and albuminoid ammonia, while as regards effluents 250 c.c. will be found to be a convenient quantity to work with.

The following analysis of samples of fair weather sewage and effluents conducted conjointly by myself and Mr. Spilsbury, F.I.C., formerly of Leamington, will show the variations in the character of sewage and the effects of purification by irrigation on the effluents. It will be noted that the Kenilworth sewage is not nearly so impure as the samples from the other towns; and that is accounted for by the fact that as the drainage of Kenilworth had only recently been carried out, there were comparatively few water-closets, whereas Leamington Warwick, and Rugby are entirely water-closet towns :—

ANALYSIS OF SEWAGES AND EFFLUENTS expressed in grains per gallon.

	Total Solids.	Chlorine.	Free Ammonia.	Albuminoid Ammonia.	Phosphoric Acid.	Suspended Matter.
Warwick Sewage . .	128·1	5·325	3·64	2·31	2·220	...
,, Effluent .	47·6	3·905	1·204	·123	·716	...
Leamington Sewage . .	91·1	11·00	13·342	·803	2·149	11·9
,, ,, . .	95·9	9·05	7·532	1·344	1·97	18·2
,, Effluent (1) .	58·8	5·60	·84	·1176	trace	...
,, ,, (2) .	49·7	4·4	·084	·0392	absent	...
,, ,, (3) .	51·1	4·4	·120	·0252	slight trace	...
Kenilworth Sewage . .	36·4	3·4	·896	·042	heavy traces	...
,, Effluent .	41·3	5·1	·196	·042	trace	...
Rugby Sewage . .	68·6	7·5	3·51	1·092	1·074	21·16
,, Effluent .	40·6	4·4	·728	·082	heavy traces	...
Birmingham Sewage . .	165·9	44·5	2·156	·798	1·253	55·72
,, ,, . .	104·3	14·5	3·514	1·078	1·253	37·52
,, Effluent .	56·0	9·7	·364	·0448	absent	...
,, ,, . .	55·3	9·7	·364	·0448	absent	...

NOTE.—Effluents (1), (2), (3), from the Leamington Sewage Farm, represent samples taken at the first outlet, then after the first effluent has passed through a filtering bed, and lastly from a brook into which this last effluent flows before discharging into the river Leam.

CHAPTER IX

IMPURE WATER, AND ITS EFFECTS ON PUBLIC HEALTH

ALTHOUGH impure water has long been recognised as one of the most potent causes of disease, it is only of recent years that minute investigation has succeeded in demonstrating the terrible mortality which it inflicts on all classes of the community. It is true that chemical analysis often fails in detecting the special impurities on which the development of certain diseases depends; it is also true that, even when impurities are detected, it is extremely difficult to estimate their exact etiological value; nevertheless, the broad fact remains, and it is founded on evidence of the most conclusive kind, that a vast number of cases of disease are attributable to the use of impure water, and there are good grounds for believing that, as investigations become more frequent and precise, a continually increasing class of such cases will be discovered. It must also be remembered that the effects of impure water, like the effects of impure air, may engender a general impairment of the health, without giving rise to well-pronounced disease.

Water impurities and their effects may be conveniently considered as follows:—Firstly, water rendered impure by an excess of mineral substances; secondly, water rendered impure by the presence of vegetable matter; thirdly, water rendered impure by animal organic matter.

Section I.—Water rendered impure by an Excess of Mineral Substances.

As all potable waters contain a certain amount of mineral matters, it is extremely difficult to decide the quantities of these gredients which may be present, either singly or collectively, without producing bad effects. This much, however, may be said, that waters of a moderate amount of hardness, provided that the hardness depends chiefly on the presence of calcium carbonate, are not found to be detrimental to health. A water of 8 or 10 degrees of temporary hardness, equivalent to about as many grains per gallon of total mineral solids, may be pronounced good and wholesome, while one of as many degrees of permanent hardness would prove injurious to many persons. With regard to the wholesomeness of Thames water, with a hardness averaging 15 degrees before boiling and 5 degrees after, the evidence given before the Royal Commission on Water Supply, 1869, is somewhat conflicting; for while Dr. Letheby considered a moderately hard water, such as the Thames water, best suited for drinking purposes and the supply of cities, Dr. Parkes maintained that the amount of hardness should not exceed 10 or 12 degrees, if possible. Mr. Simon and Dr. Lyon Playfair, on the other hand, although they did not condemn the London water on account of its hardness, both expressed themselves in favour of a softer water for purposes of health. The inference that may be drawn from this and other evidence would therefore appear to be this, that the total hardness of a good water ought not to exceed 15 degrees, nor the permanent hardness 5; or, in other words, that even in a moderately hard water, calcium carbonate must always greatly exceed the magnesium and calcium sulphates and sodium chloride.

The symptoms referable to an excess of hardness, arising from the presence of earthy salts, are mainly of a dyspeptic nature, and an excess of calcium and magnesium sulphates (7 to 10 grains per gallon) has been known to produce diarrhœa.

The special disease, however, which, more than any other, seems intimately connected with the mineral ingredients of water, is goitre. In some parts of England, such as Yorkshire, Derbyshire, Hampshire, and Sussex, it is found to prevail only in those districts where the magnesian limestone formation abounds. According to Dr. Coindet of Geneva, the disease is speedily produced in persons drinking the hard pump water in the lower streets of that town, while in other parts of Switzerland the use of spring water has been followed by the production or augmentation of the disease in a few days. In India again, the researches, more especially of Dr. M'Clellan, show very conclusively that it is found to prevail only where the magnesian limestone formation prevails. Whether lime and magnesian salts, or ferrum sulphide, as has been suggested by M. Saint-Lager, be the active agents in producing the disease, has not yet been rendered quite clear; but it appears certain that goitre is originated by water-impurities, and that these are of an inorganic and not organic nature.

The latest authorities on the subject believe the impurity to be of a metallic nature, probably some salt of iron, and explain the prevalence of the disease in localities where the magnesian limestone formation prevails, by maintaining that metalliferous earths are always to be found in those districts. In support of this view it must be admitted that in many limestone localities the disease is by no means prevalent, as, for example, in Scotland, Ireland, Norway, and Sweden, where mountain limestone enters largely into the geological formation.

I may here mention that scattered cases of the disease are by no means uncommon in the eastern parts of Warwickshire overlying the lias formation, where the well-water is hard, but they are very rarely met with in the central and western parts of the country, where the new red sandstone formation prevails.

The disease is far more prevalent among women than among men, and Dr. Thursfield, medical officer of health for the combined Shropshire Districts, has advanced the theory that it is caused in great measure by carrying weights on the head. It is more probable, however, that women are more liable to contract the disease than men because they are greater water-drinkers.

The effects of minute traces of metallic compounds in drinking water are as yet comparatively unknown. It is quite possible that the sanitary condition of a district may in some measure depend on impurities of this description, and, as Mr. Wanklyn suggests, that the salutary effect of "change of air" may be partly due to change in the minute metallic impurity in the water of the parts of the country which are visited.

Of the metallic ingredients, the effects of iron and lead have been the most fully ascertained. It would appear that iron, if present in quantities large enough to impart a chalybeate taste to the water, often produces headache, slight dyspepsia, and general *malaise*, while impregnation with lead from leaden cisterns or pipes has frequently been followed by symptoms of lead-poisoning. In the case of the ex-royal family of France, many of whom suffered when at Claremont from this species of water contamination, the amount did not exceed one grain per gallon; indeed, from cases which have since occurred, it seems probable that the habitual use of water containing from one-tenth to one-twentieth of a grain per gallon may be attended with danger. In 1886 numerous cases

of lead-poisoning occurred in many of the large Yorkshire towns, and notably in Sheffield, Huddersfield, and Bradford, which are supplied by soft moorland waters. Dr. Power, of the Local Government, who conducted an inquiry into the prevalence of the disease, suggested that the action of the water upon the lead pipes was due directly or indirectly to micro-organisms, but, as already explained, the weight of evidence attributes the plumbo-solvent properties of the water to the presence of acids.

Arsenic, copper, or mercury are only found in the drinking waters of this country in injurious quantities when streams are polluted by the washings from mines or chemical works.

Section II.—Water rendered impure by Vegetable Matter.

Vegetable matter may be present in water either in suspension or in solution. In peaty water, which is characterised by its brownish tint, the dissolved impurities sometimes do not exceed 2 grains per gallon. In the absence of a purer supply, a water of this description cannot be pronounced objectionable, provided that it is not stored in leaden cisterns, and that the supply is constant, though, as in the case of Sheffield, it may become necessary to treat the water so as to deprive it of its plumbo-solvent properties. If stored in open-air ponds or reservoirs it is improved by oxidation and light; and it is further improved by filtration through gravel and sand.

Water containing a considerable amount of vegetable matter, partly in suspension and partly in solution, is decidedly unwholesome. It has been known to produce violent outbreaks of diarrhœa, and since the days of Hippocrates downwards, it has been popularly acknowledged to be productive of ague and other malarious ailments. In this country there are several instances on

record that ague has been much lessened in small communities by using well instead of surface water; and there is strong presumptive evidence that, apart from the influences attaching to improved drainage, the great decline of this disease throughout many parts of England, where it formerly prevailed, is in some measure due to the use of purer water.

Section III.—Water rendered impure by Animal Organic Matter.

From a sanitary point of view this is by far the most important class of water impurities. The presence of putrescent animal matter, whether it has percolated through the soil from cesspools or other filth-accumulations into wells, or whether it has been discharged from open sewers into streams and rivers, converts drinking water into a dangerous poison, fraught with disease and death. It is true that to a certain extent the process of filtration through a porous soil tends to render less hurtful the sewage which dribbles into a well, but after a time this purifying power is lost, the soil becomes sodden, and the sewage enters unchanged. It is also true that, given a sufficiently large stream, a sufficient length of course, and a sufficient length of time, the greater portion of the sewage discharged into a river will become converted into harmless products by oxidation. Yet neither process can be trusted, however complete it may appear to be. There is always danger lurking in a water which is known to be contaminated with animal matter, and more especially when such matter is partly composed of the evacuations of patients suffering from certain specific diseases, such as cholera or enteric fever. The germs of disease which may be communicated in this way have a tenacity of life or chemico-physical power altogether beyond our knowledge.

Leaving out of consideration the question whether animal organic matter in suspension or in solution is the more injurious to health, it would appear that it is the quality rather than the quantity which determines the danger. As already stated, a trace of fæcal matter, especially when undergoing active chemical change, may render a public well poisonous, while a stream of sewer-gas may contaminate the contents of a cistern, and be the means of prostrating a whole household.

The principal diseases which have been proved to be produced by this class of water impurities are cholera, enteric fever, dysentery, and diarrhœa.

1. *Cholera.*—Although much had been previously written with regard to the etiology and spread of cholera, it was not generally surmised that the disease could be propagated by a polluted water-supply until the late Dr. Snow published the results of his researches in 1849. At first Dr. Snow's views were rejected by some, or questioned by others; but in 1854 there occurred a violent outbreak of cholera in the parish of St. James, Westminster, the causes of which were inquired into by a committee of medical men, whose report fully substantiated Dr. Snow's conclusions. Between the 31st August and the 8th September of that year as many as 486 fatal cases occurred within an area bounded by a circle whose radius scarcely exceeded 200 yards. On inquiring into the local peculiarities of the epidemic, Dr. Snow found that the sufferers had been in the habit of drinking the water supplied by a pump-well in Broad Street, which had a great reputation for freshness and sweetness. An analysis of the water proved that it was highly charged with animal impurities, and, at Dr. Snow's earnest solicitation, the handle of the pump was removed by order of the vestry on 8th September, to prevent further use of the water. After this the disease gradually subsided, and

ultimately disappeared. It was made manifest by a subsequent examination that the sewage of a neighbouring house had leaked into the well, and it was further ascertained that the evacuations of a patient residing in the house, and who was suffering from diarrhœa, or actual cholera, must have mingled with the sewage immediately before the occurrence of the general outbreak.

The subsequent cholera epidemics in London of 1855 and 1866 afforded equally conclusive evidence of the intimate relations existing between specifically polluted water and the incidence of the disease ; and indeed the opinions of Professor von Pettenkofer, though at first sight they appear to be antagonistic to the water origin theory, do in reality support it. For, while he considers that the propagation of cholera is due to a fermentation of the rice-water stools, he also maintains that this ferment can only act, and the contagion be generated, under certain local conditions—namely, when there is a damp porous subsoil to receive the ejecta. Although Pettenkofer believes that the air is the sole channel by which the cholera miasm, thus generated in the soil, is spread, there is no doubt that the bearing of the geological influence amounts only to this,—that where populations are living on a damp open subsoil, with no artificial water-supply, nor any efficient system of drainage, there the drinking water, as well as the local atmosphere, is almost certain to be largely polluted by those fæcal impurities amid which the diarrhœal contagia are peculiarly apt to multiply.—(*Simon.*)

Whether cholera can be produced by animal organic matters not of a specific nature is still an open question. Very probably the effect of constantly drinking a certain amount of these impurities produces a lowered state of the system and a tendency to diarrhœa, so that, when the cholera poison is abroad in the atmosphere, it finds its victims in largest numbers amongst those who partake of

an impure water-supply. This much, however, appears certain, that whenever cholera evacuations make their way into the drinking water, we may expect to find the disease burst forth with the greatest virulence and fatality amongst those who use the water, and that indeed the endemic area will approximate with remarkable closeness to the limits of the district which it supplies. Even in those parts of India where the disease is endemic, the reports of sanitary officials afford abundant evidence of the intimate relations which subsist between cholera outbursts and specifically polluted water. Indeed, the grossly filthy habits of the natives cause such constant pollution of the water in the tanks from which vast numbers obtain their entire supply, that the disease is always more or less prevalent.

2. *Enteric or Typhoid Fever.*—The remarks which have just been made with regard to the influence which impure water exerts on the spread of cholera apply with still greater force to the etiology of enteric fever. For, whatever views may be entertained concerning the *de novo* origin of the disease, there can be no question that it is more frequently spread through the medium of water than in any other way. It is worthy of note, too, that enteric fever when due to infected water has usually a shorter period of incubation than when it is propagated through the agency of infected air, and attacks a larger number of persons exposed to the risk of infection.

Amongst the numerous local outbreaks which have been investigated by the Medical Inspectors of the Privy Council, and subsequently of the Local Government Board, the following may be noticed rather as examples of the painstaking and systematic way in which such inquiries should be conducted than as proving this mode of enteric fever :—

(1.) The account of the epidemic at Terling in Essex in 1867, by Dr. Thorne Thorne, is valuable as showing

the effect of a sudden rise of the ground water-level in a village situated on a porous subsoil, obtaining its water-supply from shallow wells, and allowing its excrementitious filth to accumulate in badly constructed privies and manure heaps, or to lie indiscriminately in scattered masses on the surface of the ground. Out of a population of 900, about one-third of the number were attacked with enteric fever within a period of two months, and 41 had died. Some ten days before the outbreak, and after a period of prolonged drought, a sudden great rise in the water-level of the wells was observed to follow a heavy fall of rain and snow; in other words, the shallow unprotected wells sunk in the porous gravel had become converted into so many receptacles for the washings of the filth-sodden soil, and hence the epidemic.—(*Tenth Report of the Medical Officer of the Privy Council.*)

(2.) In the beginning of 1873 a severe outbreak of enteric fever occurred in the small town of Sherborne in Dorset, which was investigated by Dr. Blaxall, and which is of extreme interest as having been the first outbreak of the kind which was clearly traced to the entrance of sewer air into the water-mains. Although the water-supply was intended to be constant, it was ascertained that in December 1872 and January 1873 the water was frequently shut off at a point near the reservoir, and that during the month of February it was shut off every night. It was observed that when the water was turned off there were certain water-mains up which there was a sudden rush of air immediately the tap was unscrewed, and as many of the mains communicated directly with closet-pans by means of taps, which were sometimes left open, and which in other instances were broken, there were thus numerous inlets for the entrance of air from the closet-pans into the water-mains. Moreover, if a pan happened to become full of excremental filth, there was

the probability of excrement as well as sewer air having been sucked into the mains. In January and February there were about 27 cases of fever in the town, but before the end of April the number altogether had increased to 240, out of a population of 6041. After the first week, during which 73 cases occurred, the water-supply was again made constant, and the epidemic gradually declined. —(Mr. Simon's *Reports*, New Series, No. II.)

(3.) Somewhat akin to this outbreak in its mode of causation was the outbreak of enteric fever which occurred at Caius College, Cambridge, towards the close of 1873. Dr. Buchanan's report on this outbreak is such a model of painstaking research and sound reasoning that, apart altogether from its intrinsic value as a contribution to the etiology of fever, it ought to be read by every medical inquirer as one of the most lucid expositions in the domains of medical logic. Without detailing at any length the various interesting phases of the inquiry, it will be sufficient here to state that the cases of fever numbered 15, that the incidence of these cases was wholly upon the 112 students who were resident in the college, and that 12 out of the 15 cases were confined to 63 students, residing in a particular part of the college, namely, Tree Court. After considering all the more usual ways in which enteric fever is known to be spread, and finding that none of them could account for the intensity of the incidence of the outbreak in Tree Court, Dr. Buchanan's suspicions were directed to the water-supply. Now, the water-supply of the college was taken from a surrounding 5-inch main at six different places, and at one of them, namely at the Gate of Humility, there was a branch main which supplied Tree Court and no other part of the college. In short, the area of this particular water distribution was the area of the fever, and although there was no doubt that the

quality of the public water-supply was good, this was no argument against a "local contamination in a local service." It had struck Dr. Buchanan at an early stage of the inquiry that the closets in Tree Court were the only closets in the college which were not provided with cisterns, but were supplied with water direct from the high-pressure constant main; and on further inquiry the following facts were ascertained:—(1) That, according to the servants, there was occasional intermission in the constant service of water-supply; (2) that there had been two actual intermissions during the term, one of which occurred about 25th October, or a fortnight before the first case, and the other certainly on 1st November, a fortnight before the date of the second, third, and fourth attacks; and (3) that, although the mains were supplied with valve-taps which were believed to prevent any regurgitation of air or water, it was clearly proved by experiment that there was a reflux of air and water into the main when the water was turned off, and that the valve-tap was useless in this particular instance for the purpose for which it was intended. This view of local contamination of the water-supply was further substantiated by an analysis of the dirty-looking layer which was found to line the pipes, which showed that the layer consisted of a large proportion of nitrogenised organic matter and phosphoric acid, clearly showing that liquid filth as well as sewer gas had entered the pipes.—(Mr. Simon's *Reports*, New Series, No. II.)

(4.) Another outbreak investigated by the late Dr. Page, one of the Medical Inspectors of the Local Government Board, occurred in the Houghton-le-Spring Rural Sanitary District in 1889, and was somewhat remarkable, inasmuch as it was associated with a certain amount of a low form of pleuro-pneumonia. So sudden was the outbreak, that between 16th and 24th April as many as

100 cases had cropped up out of a population of 4400, which obtained its water from a particular public supply, the number of cases subsequently mounting up to 258. Although, by exclusion of other possible causes, the water was suspected from the first, chemical analysis did not confirm this opinion; but on more extended investigation at the source of supply it was discovered that there was a small feeder which entered the well or "staple" at a depth of 45 feet from the surface, and that this showed distinct indications of organic impurity with an amount of chlorides exceeding that found in the water of the well. On looking around for other possible sources of pollution beyond the immediate vicinity of the well, Dr. Page had visited a farmhouse and buildings about three-quarters of a mile from the well. The house and buildings and an adjoining cottage were situated on the magnesian limestone at a height of about 150 feet above the surface of the well, and the drainage from the house water-closet, the farm buildings, and cottage were conveyed into a tank. Owing to subsidences caused by the colliery workings below, it was found that fissures extending to the surface existed in the locality, and the overflow from the tank disappeared down one of these fissures. To determine whether there was any connection between this fissure and the water-bearing strata supplying the well, Dr. Page had five tons of salt washed down the crevice, when the chlorine in the feeder mounted next day to 15 grains per gallon, and subsequently to 24 grains, clearly proving, to quote the words of Dr. Buchanan, that "there were good grounds for believing that matters polluting a water-service had been carried along three-quarters of a mile in a fissure of magnesian limestone."

Although in these several epidemics, and many others which have been investigated, there was no direct evidence to show that the water was specifically polluted, the

following outbreaks are strongly corroborative of the view that the disease is essentially a specific disease, and can only be propagated by means of a specific contagium.

(*a.*) The outbreak at Over Darwen, which occurred towards the close of 1874, is alike remarkable for its terrible severity and for the thoroughness with which the cause of the outbreak was traced to its origin. According to Dr. Stevens, who was appointed by the Local Government Board to inquire into and report upon the epidemic, the first case occurred at a house some considerable distance from the town, but not very far distant from the public water-main. The patient, having contracted the disease elsewhere, afterwards came home ill, and died there. On first inquiry it was stated that the water-supply could not by any possibility be polluted by the excreta from this case, but subsequent investigations rendered it only too apparent that here lay the whole cause of the epidemic. It was discovered that the drain of the closet into which the excreta of this patient were thrown crossed the line of the water-main, and though special precautions had been taken by way of cementing and the like to prevent any leakage, it was found that the drain had become choked up, that the cement had given way, and that the contents of the drain were sucked freely, indeed regularly, into the water-main. No doubt the general filthy condition of the town greatly aided in propagating the epidemic after the specific contagium had been distributed by means of the water-supply, but the terrible rapidity with which the disease spread pointed clearly to specifically polluted water as being the prime cause of the epidemic. Out of a population of about 22,000, 2035 people were attacked within a very short period, and of those 104 died.—(*Local Government Board Reports*, 1875.)

(*b.*) In the small village of Lausen in Switzerland

there occurred an outbreak of enteric fever in 1871 which proved that even filtration through a considerable tract of porous soil will not purify water which has once been specifically tainted. It was found, when the outbreak was investigated, that all the houses in the village, with the exception of six, were supplied with water by means of wooden pipes from a certain spring, and that the outbreak was confined to the inhabitants who drank this spring water, the other inhabitants, who drank well-water, having entirely escaped. That the disease had been introduced by the spring water was made clear by the following facts:—Behind the village there is a hill about 300 feet high, the westerly spur of which extends into a small side valley, and through this valley runs the Furler brook. Connected with this brook there were the latrines of several scattered farmhouses, in one of which four persons had suffered from enteric fever in the months of June and July. Although at first sight it did not seem possible that there could be any connection between these cases and the outbreak at Lausen, it was ascertained that when the meadows in the Furler valley were watered by damming up the brook, the spring increased in amount, and that when they were thus treated in July it yielded a turbid and bad-tasting water. Not long afterwards, namely, on 7th August, 10 inhabitants were attacked, and in nine days more 57 persons were prostrated with the disease, the number reaching to 130 at the end of October. To prove that the Furler brook could contaminate the spring at Lausen, the experiment was tried of putting common salt into the brook, when it was discovered that the spring water became quite briny.—(*Deutsch. Arch. für Klin. Med.*, 1873.)

(*c.*) In the early part of the year 1879 there occurred a severe outbreak of enteric fever at Caterham and Redhill in Surrey, in which within a period of

about six weeks there were about 370 cases and 21 deaths. The outbreak was investigated by Dr. Thorne, and his report, apart from its painstaking nature, is of special interest, inasmuch as the disease was brought about under conditions which stand alone in the history of such epidemics. Briefly, it was discovered on careful inquiry that the outbreak was traceable to the circumstance that one of the workmen employed about a fortnight previously in driving an adit leading from an old well to a new bore at the Caterham water-works had been suffering from diarrhœa and typhoid symptoms, and that for several days the diarrhœa was so severe that he was compelled to evacuate in the adit. On the completion of the work the water thus became specifically polluted, and the distribution of the disease was found to be limited to houses supplied by the Caterham Company.

The following outbreak merits particular notice on account of its unique character, and as being the first of the kind reported. During the course of the first week in August 1882 Mr. George Fosbroke, medical officer of health for the Combined Stratford-on-Avon District, was called upon to investigate an outbreak of enteric fever which had suddenly assumed unusually extended proportions in the town of Evesham and the adjoining neighbourhood. Before the close of September as many as forty-eight cases had occurred in the borough, and twenty-one in the rural districts, five of the former and three of the latter having proved fatal. The suddenness of the outbreak, widely scattered though many of the cases were, pointed to some common cause; and, after careful inquiry, Mr. Fosbroke discovered that all the patients first attacked had attended a regatta held at Evesham on 12th July, and further, that they had all frequented a particular meadow adjoining the river Avon. Still more extended inquiry disclosed the fact that all these persons

had partaken of "spirits, lemonade, or ices" while on the meadow, and that the water used either for diluting the spirits or manufacturing the lemonade and ices was obtained from a well which was subsequently found to be contaminated with sewage; but whether specifically contaminated was not quite clear, although suspicions strongly pointed in that direction. In any case, there is no doubt that the water from this well used for the manufacture of the lemonade was the cause of the outbreak, and subsequently, by direct or indirect means, affected no less than 113 persons.—(Mr. Fosbroke's *Report* for 1882.)

But in country districts there occur many scattered cases of enteric fever, which, although they have a water origin, cannot be traced to specifically polluted water. According to my own experience, and it accords with that of many other health officers who have studied the etiology of enteric fever in rural districts, the disease is frequently produced by drinking water which is found to be polluted with animal matter, but not with specifically tainted matter. As regards these cases, the most careful inquiry has failed to discover any connecting link between them and pre-existing cases, while in all of them it has been found that the well-water has been polluted by leakage from some cesspool, privy, or drain. It may be said, therefore, that, though they are essentially pythogenic, they are not specific. All this, however, will be discussed more fully in a subsequent Chapter. (See Chapter XV.)

(4.) *Diarrhœa and Dysentery.*—In addition to numerous outbreaks of diarrhœa which have been recorded as due to direct sewage contamination, there have been many instances in which the disease has been traced to water contaminated by sewer-gases, as when the overflow pipe from a cistern supplying drinking water is directly connected with a drain or sewer, or when the same cistern which supplies a water-closet also supplies the drinking

water. There is no doubt, however, that, as in the case of contaminated air, the system from long habitude becomes tolerant of polluted water which often produces a marked effect on those who drink it for the first time. The instances of outbreaks of dysentery which have been traced to the presence of animal impurities in drinking water are so numerous, especially in Eastern countries, that the mere mention of the fact will suffice.

According to my own experience, much of the diarrhœa which prevails in country districts during the summer and autumn amongst children is due to polluted water drunk either as it is drawn from the well or when mixed with milk.

Concluding Remarks.—Although an attempt has thus been made to classify roughly the hurtful impurities of water, and the diseases which they may severally produce, it need hardly be said that in the great majority of instances of faulty sanitation connected with water-supply, there is often a combination of impurities and of diseases both. For example, the analysis of waters which have proved to be decidedly injurious shows that in general the impurities are numerous; and, on the other hand, not one but several diseases may be either directly produced or indirectly influenced by them. And this difficulty of apportioning to special impurities their special effects is frequently increased by the presence of other causes of disease. Thus, the water may not only be polluted, but the supply may be scanty, and thereby give rise to great want of cleanliness of the person, of clothes, of cooking utensils, and of the general surroundings; while overcrowding, defective sewage-removal, badly ventilated drains, and other causes of disease, may also co-operate in seriously affecting the health of a community and largely increasing the death-rate.

Amongst other diseases which have sometimes a water origin may be mentioned ulcerated sore throat, diphtheria, and febricula. Indeed, in purely country districts what is known as low fever is essentially a filth fever, but often presenting ill-defined symptoms, and is found to be associated in the great majority of instances with polluted well-water. Outbreaks of yellow fever in foreign countries have been traced to water polluted by the discharges of patients suffering from the disease, but this is not a common mode of propagation.

It would also appear that the prevalence of calculous disease and gravel bears some relation to the amount of lime and magnesian salts contained in the drinking-water of certain parts of the country. This disputed subject has been carefully investigated by Dr. Murray of Newcastle-upon-Tyne (*Brit. Med. Journal,* 1872); and his statements, together with the cases which he adduces, are strongly corroborative of this view, but general statistical evidence is wanting.

Finally, it has to be noted that several of the entozoa find their way into the body through the agency of drinking-water, as, for instance, the *Tænia solium*, *Bothriocephalus latus*, and the *Ascaris lumbricoides*. The last-named, which is known as the *round* worm, I have found to be common in districts where the water-supply is chiefly obtained from shallow dip wells. There is reason to believe, too, that the *Oxyuris vermicularis* (*thread* worm) has often a water origin. Indeed the embryos or eggs of all of these and other parasites have been found in water, and so may be taken into the stomach when such water is used for drinking purposes. (See Chapter XV.)

CHAPTER X

REMOVAL OF SEWAGE AND HOUSE REFUSE

In all inhabited places it is of the utmost importance to the health of the community that efficient arrangements should be made for the collection and removal of the excrementitious matter thrown off by the bowels and kidneys, the waste waters from houses, and the dry refuse, such as ashes, dust, and refuse food, which keep constantly accumulating. In towns these refuse matters are largely supplemented by the dung and urine of animals, street sweepings, and the waste waters from manufactories. The liquid refuse, to which the term sewage is applied, is removed by a system of drains and sewers; while the collection and removal of dry refuse is included under the term scavenging.

The amount of solid excreta passed by an adult male living on a mixed diet has been estimated at 4 oz. daily, and the amount of urine 50 fluid ounces. In a mixed population, however, the average amount per head, according to the late Professor Parkes, may be stated as $2\frac{1}{2}$ oz. fœces and 40 oz. urine. Both fœces and urine are slightly acid when first passed, and will remain so for some time if they are kept separate, but when they are mixed, as in cesspools, privies, and sewers, they rapidly undergo decomposition and give rise to the formation of foul and offensive effluvia. The urea in the urine is speedily decomposed into carbonic acid and carbonate of

ammonia. The average daily amount of nitrogen in the fœces and urine together yielded by a mixed population is 150 grains. This corresponds to about 10 lbs. of ammonia per annum, six-sevenths of which are contributed by the urine, and only one-seventh by the fœces.

In almost all villages and in many large towns, the human fœces and a certain amount of the urine are collected under what is known as the *conservancy system*,—in pails, dry closets, privies, cesspools, or ash-pit middens; but in the great majority of towns what is called the *water-carriage system* is adopted, in which the excreta and the urine are removed along with the liquid refuse by means of drains and sewers. Where there is no unusual difficulty in dealing with the sewage at the outfall, there can be no doubt that the water-carriage system of excretal removal is the one best suited for populous localities, for, apart from considerations of cleanliness and convenience, this system possesses the additional advantage of employing the same channels for the removal of excrementitious matters which are required in every locality for the removal of waste waters, and it does away with difficulties attending efficient scavenging which often become very formidable. Indeed it is found that the sewage of non-water-closeted towns is only slightly less foul than the sewage of towns in which the water-carriage system has been adopted in its entirety; and this can be well understood when it is remembered that in addition to the house waste waters, which are highly charged with organic matter from household slops and the grease and dirt from washing, there is the liquid refuse from stables, cowsheds, public urinals, slaughter-houses, manufactories, and all the filth contained in the washings from yards and street surfaces. It is clear, therefore, that even though all the solid excreta were disposed of by a system of conservancy and scavenging,

drains and sewers are still required for the removal of the liquid refuse, and this refuse is so foul that it cannot be discharged into any river or stream without causing serious pollution unless it is first efficiently purified.

In describing briefly the various methods which have been adopted for the removal of sewage and house refuse, it will be convenient to discuss the subject under the following sections:—

1. The water-carriage system.
2. Conservancy methods.
3. Lieurnur's and other continental methods.
4. Methods best suited for rural districts.
5. Public scavenging.

Section I.—The Water-Carriage System.

While there is no doubt that the introduction of water-closets greatly increased the dangers attaching to faulty drains and leaky cesspools, it has also been made abundantly clear that with drains properly constructed, properly ventilated, and kept properly flushed, and with sanitary appliances of approved type, not only may all such dangers be obviated, but health, cleanliness, and convenience can be better secured by the water-carriage system than by any other method of sewage removal. Unfortunately, however, many of the old defects connected with faulty sanitary appliances, ignorant plumbing, and badly-constructed drains, are still so common in towns, and especially in country houses provided with water-closets, that complete sanitary safety is far from being secured. Indeed, it may be said that no house, whether in town or country, in which there is a water-closet can be considered safe whose drainage and sanitary appliances have not been entirely remodelled within the

last ten or fifteen years on approved and scientific principles, and this applies alike to fittings and drains.

1. Sanitary Fittings.—(1.) *Water-Closets.*—According to the model bye-laws of the Local Government Board, every water-closet in a house should be built against an outside wall, and be properly lighted and ventilated. The minimum amount of window space enjoined is two feet by one foot, and additional ventilation should be provided by the insertion of at least one air-brick built in the external wall, or "by an air shaft, or some other effectual method or appliance." In very many of the older houses, however, the water-closet is situated either in the centre of the house or in out-of-the-way corners where only borrowed light can be obtained, and efficient ventilation becomes next to impossible. Even with every precaution as to interception of the closet drain and attention to other details, a water-closet so situated cannot be used without tainting the air of the house to a certain extent. As regards large houses, public institutions, and dwellings in flats, the best position for the water-closet is in one or more isolated blocks or projections built tower fashion, and abutting against outside walls. Efficient cross ventilation can in this way be secured between the closets and the interior of the buildings.

There are now so many kinds of closets well arranged in all their details that it is difficult to say which of them are most to be commended. There are others, again, such as the pan closet with D-trap and container, or the long hopper closet with insufficient flush, which cannot be sufficiently condemned, although both are still very largely used. Indeed, the pan closet (see Fig. 7) is perhaps still more frequently found in the better-class houses than any other kind of closet, although pan and trap soon become coated and exceedingly foul, and the D-trap, which is made

of lead, is very often found perforated in places owing to the chemical action of the excreta and gases on the lead. This kind of closet is never safe, and its use is absolutely prohibited in all new houses wherever the model bye-laws of the Local Government Board have been adopted. The long hopper closet, on the other hand (see Fig. 8), is still very common in the poorer parts of towns. The basin becomes foul owing partly to its faulty form, but mainly to the insufficient water supply with which it is generally provided, and which swirls round the pan without cleaning it thoroughly.

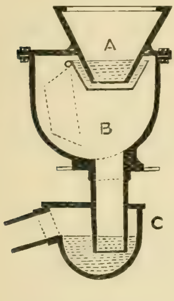


Fig. 7. Pan Closet.
A, Basin; B, Container; C, D-trap.

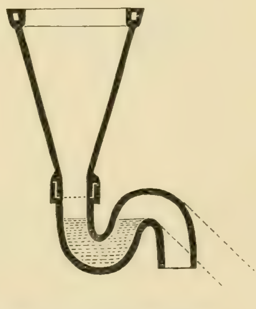


Fig. 8. Long Hopper Closet.

Generally speaking, the best kinds of water-closets are those which provide for good flushing, and rapid and complete removal of the excreta without permitting reflux of foul air. They may be divided into two classes, namely, those in which there is no movable apparatus to retain water in the basin, and those in which a movable apparatus is used for that purpose. Under the first category are included the *short hopper* or *flush-down* closet, and the *wash-out* closet; and under the second, valve and plug closets.

The *short hopper*, *flush-down*, or *deluge closet*, as it is

variously called (Fig. 9), is constructed of a short cone of china or earthenware connected beneath with a syphon trap which retains sufficient water to prevent the reflux of air. The back of the basin should be vertical or nearly so, in order that the excreta may drop into the water in the trap, and not upon the sides of the basin, as in the long hopper closet.

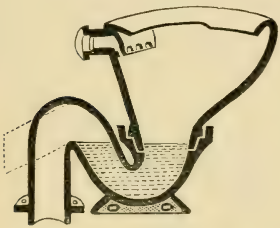


Fig. 9.—Short Hopper or Flush-down Closet.

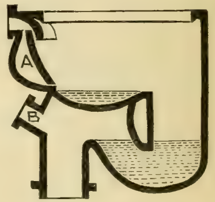


Fig. 10.—Wash-out Closêt. A, After Flush-Chamber; B, Trap Ventilator.

The *wash-out closet* (Fig. 10) has a dip in the basin which contains a small quantity of water to receive the excreta. The flush of water from the cistern clears the contents of the basin over the edge into the syphon trap beneath, and the rush ought also to be sufficient to clear the syphon; but as the edge of the basin breaks the force of the water, it is not always easy to keep the syphon perfectly clear, even with a flush of two gallons. In order that some water may remain in the dip of the basin, these closets are provided with a small chamber which discharges a certain quantity of water called the "after flush." On the whole, the short hopper closet is preferable to the wash-out, because it can be more effectually flushed, and is therefore less liable to become foul, and because it contains sufficient water to cover the excreta.

What is called the *Dececo closet,* which comes from America, is of the flush-down or short hopper type, has

no mechanism, has a deep water receiver and trap for the excreta, and discharges by syphonic action. It does not appear, however, to possess any advantages over the short hopper closets, except that the trap is more efficient.

These different forms of closets should be provided with waste-preventing cisterns holding 2 to 3 gallons of water, and to secure a good strong flush the supply-pipe should be at least $1\frac{1}{4}$ inch in diameter. Larger cisterns are often used, but on no account should any cistern which supplies water for drinking purposes be used for the direct supply of any closet. Formerly the great majority of long hopper closets were supplied direct from the mains by means of stool-taps; but, as pointed out in the previous chapter, such an arrangement is fraught with the great danger of polluting the water-supply by the entrance of foul air or liquid filth from the closet basins into the mains, and has occasioned numerous outbreaks of typhoid fever. Where there is no house cistern, and the water-supply is constant, these waste-preventing cisterns are especially necessary, and the best form is that with a syphon action. By a very short pull of the chain the syphon is set in action, and the whole contents of the cistern are discharged into the closet basin.

Many of these closet basins are fitted with a slop tray, or so shaped that they may be used as slop sinks or urinals; and with the exception of a hinged seat, all other woodwork may be dispensed with, and thorough cleanliness of the closet secured.

Another objection which is often raised to flush-out or flush-down closets when situated in the upper floors of houses is the noise made by the rush of water in flushing and the emptying of the waste-preventing syphon cistern, and on this account many prefer either the *valve closet* or the *plug closet*, both of which are comparatively noiseless when used. Each of these closets should be flushed

from a small cistern containing from six to eight gallons, and not from a waste-preventing cistern, as it is necessary to provide for an after-flush.

The *valve closet* (Fig. 11) consists of a semi-spherical basin of china or earthenware, with an opening 3 inches in diameter at the bottom, which is closed by a circular water-tight valve, hinged at one side, where it is connected with the handle. On raising the handle, the valve is depressed into a metal box just large enough to permit the valve to fall back into the upright position, and so permit the contents of the basin to pass freely into the syphon trap beneath.

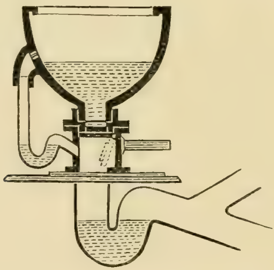


Fig. 11.—Valve-Closet.

In order to secure an after-flush to charge the basin after the closet has been used, some form of valve-regulator, such as the piston-regulator, connected with the supply-pipe from the cistern and worked by the handle, is required. This is so arranged that after the closet valve is closed, the valve in the supply-pipe is kept open and admits as much water as will sufficiently charge the basin and no more. But in order to permit of an overflow when slops are thrown in or when there is too much after-flush, an overflow pipe is required, which discharges into the valve-box, and thence into the syphon trap beneath. This overflow pipe is trapped by a syphon bend

to prevent the passage of any foul air when the closet contents are discharged.

With this kind of closet the apparatus must rest on a safe-tray, and it is preferable that the syphon trap should also be above the floor level; but the whole of the wood-work which is required to conceal the apparatus, together with the seat, should be made movable, in order that the safe and the other parts under the seat can be readily cleaned.

The *safe-tray*, on which the closet apparatus rests, is made of zinc or lead, and is intended to catch any over-flow. It should be provided with a syphon-trapped waste-pipe, which must be carried through an outside wall so that it may discharge into the open air. Formerly it used to be the practice to connect this pipe with the filthy D-traps which were so generally used beneath this and the pan closet, thereby permitting a constant current of foul air to enter the house.

The *plug closet* somewhat resembles the wash-out closet, with this exception, that a much larger quantity of water is retained in the basin by means of a plug or plunger, which completely closes the arm leading from the basin to the syphon (see Fig. 10), and which is pulled up when the handle is raised. Both basin and trap are usually manufactured in the same piece of china or earthenware, but the closet is open to the serious objection of the plunger becoming fouled by excreta, and its free action impeded by lodgement of pieces of paper. The flushing and cistern arrangements are generally similar to those required for the valve closet, an after-flush being necessary for both alike; but some manufacturers now arrange to flush from a waste-preventing cistern.

(2.) *Trough closets.*—For schools, factories, large work-shops, public institutions, and groups of houses in crowded courts, trough-closets are especially suitable. This form

of closet consists of an open trough, rounded at the bottom and made of cast iron specially coated, or glazed earthenware, and is of varying length according to the number of compartments required. The trough should slope slightly towards the drain, and by means of a lip or weir at the lower end a certain quantity of water is always retained to receive the excreta. The closet is best flushed by a Field's annular syphon flush-tank (Fig. 12), and the frequency of the discharge can be regulated by

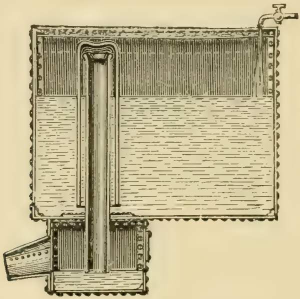


Fig. 12.—Field's Syphon Flush Tank.

adjusting the tap supplying the tank or cistern, a small dribble being usually quite sufficient, provided the tank has been so fixed that the long arm of the syphon is perfectly perpendicular. As the cistern works automatically, effectual flushing is provided without requiring any attention beyond adjusting the tap so that the cistern may discharge itself as often as may be required. The trough should communicate with the drain by means of a syphon trap, and this should be protected by a screen or gird to retain any articles which may be improperly thrown into the drain. Each seat over the trough should be separated by partitions, and these may be provided with doors if deemed necessary to secure privacy when the closet is used.

Trough closets are admirably adapted for crowded

courts, and should be much more extensively used than they are at present; but to prevent mischievous interference the flush-cistern should be placed in a locked compartment, accessible only to the sanitary inspector or some other responsible officer.

In Birmingham, closets have been constructed on a similar principle, but they are flushed by household slops. The drainage from a row of houses conveys the waste water to an automatic flush-tank or tumbling-basin which is placed at the end of the row farthest from the sewer. From this tank a large pipe-drain leads to the sewer, and separate closets are built over its course. Instead of a pan or basin, these closets have simply a large drain-pipe, which is connected vertically or sloping slightly backwards with the drain beneath, the excreta dropping directly into the receiving drain and remaining there until the next flush from the tank or tipper sweeps them away into the sewer. Between the sewer and the lowest closet the drain is intercepted by a syphon trap, and at this point a manhole is constructed which is used in the event of obstruction.

A similar arrangement has been devised for utilising the waste water of separate houses to flush single closets, but instead of a syphon flush-tank, a tilting-trough or tipper may be placed under the grating on to which the sink-pipe discharges. This tilting-basin or tipper flushes the drain by emptying its contents whenever it becomes full, and the seat of the closet is placed directly over the syphon trap which disconnects the drain, so that the fœces drop directly into the syphon.

(3.) *Urinals.*—In private houses urinals should be dispensed with altogether, unless they can be fixed in a perfectly suitable position, where an abundant supply of water can be obtained. The urinal itself should be small, neat, and of pure white porcelain or earthenware.

The waste-pipe should, if possible, deliver out into the open air or be otherwise intercepted, or into a drain if properly trapped. It may, however, be made to discharge into the soil-pipe. The floor or a portion of it should be laid with glazed tiles of a light colour.

Public urinals should be made of non-corrosive materials, such as enamelled slate, glazed earthenware, or vitrified fire-clay, and their waste-pipes should discharge over a channel in the floor, which should be properly paved or cemented. They are best flushed by means of automatic flush-tanks.

(4.) *Housemaids' slop-sinks.*—In large houses these are perhaps a greater source of danger than water-closets unless proper precautions are taken as regards trapping and ventilation of waste-pipes. Indeed, they should be dispensed with altogether whenever the closet is suitable for the reception of slops. They are generally of conical or square form, and made of glazed china or earthenware with syphon trap beneath. They should be fixed on a leaden tray or safe provided with a waste-pipe discharging into the open air. An open brass grating should be fixed at the bottom of the sink to intercept cloths or other articles. Although it is necessary that the sink should be furnished with means for flushing, it is preferable that it should be flushed from a waste-preventing cistern than by means of a tap, because the latter may be used by servants for filling water-bottles. These should be filled from a tap or taps discharging over a house-maid's trough, which may be conveniently fixed near the sink but on a higher level, so that the waste-pipe may discharge into the sink, but not directly into the waste or soil-pipe.

Pantry or scullery sinks are frequently made of glazed earthenware, but lead-lined sinks are preferred wherever glass or china is washed up, to prevent breakage.

(5.) *Baths and Lavatories.*—The materials and arrangements of these accessories of civilised life are of endless variety, and do not admit of discussion here. But for purposes of cleanliness, the cast-iron bath, well painted, and without any woodwork, is found to answer very well. Such a bath should be placed on a lead tray with waste-pipe discharging into the open air, and the waste-pipe from the bath itself and from any lavatory basin should also be made to discharge in the open in an absolutely pure position. In ordinary bath-rooms the paper should be varnished.

2. House Drainage.—(1.) *Soil-pipes.*—Wherever possible, all soil-pipes should be fixed against external walls, and carried up full bore to a point above the eaves and away from sky-lights, windows, or chimneys. The top or outlet should be provided with a copper wire cage instead of a revolving cowl or ventilator, because the former is liable to become fixed, and the latter may become obstructed owing to birds selecting it for nest-building. The soil-pipe should preferably be fixed a foot away, sideways, from the branch coming through the wall from the closet, and by means of special clips or brackets it should be firmly supported, so as to allow a free space between the pipe and the wall, thus giving access to make secure joints, to paint the pipes when necessary, and to prevent dampness of the wall. The best size for a soil-pipe is 4 inches diameter; and though many plumbers prefer drawn-lead piping as the most suitable material, cast-iron pipes are now generally used on account of their cheapness; but in all cases they should be heavy, and coated with Dr. Angus Smith's composition inside and out, and the joints should be made with yarn and molten lead. If drawn-lead piping is used it should weigh at least 7 or 9 lbs. per square

foot, according to the height of the building, and the joints should be what are called *wiped* joints, which ensure continuity of bore inside the pipe without any projections. Lead T-pieces are often used to connect the branches from the water-closets with the soil-pipe, even when the soil-pipe is made of iron, but great care in plumbing is required to secure proper jointing, and the joint should never be made in the thickness of the wall. Whether the branch connecting the water-closet with the soil-pipe be of lead or iron, it is essential that the closet-trap should be provided with a flange in order to secure a smooth and firm junction between the two, or a brass collar may be fixed on the end of trap into which the branch pipe can be more securely jointed. Then, again, in jointing the soil-pipe into the house drain, when this consists of earthenware pipes, flanges should be affixed to the soil-pipe so as to grip the cement firmly, and such joints should be always vertical and never horizontal.

When several closets discharge into the same soil-pipe, as in lofty houses, or houses built in flats, special provision must be made to prevent syphonage of the traps of the lower closets when an upper closet is used. This is effected by ventilating the out-go bend of every closet-trap separately into an anti-syphonage pipe carried alongside the soil-pipe from the lowest closet to above the eaves, or it may be joined into the soil-pipe above the highest closet. Another plan is to use what are called anti-D traps instead of the ordinary closet syphon trap. They possess a sharp bend at which they contract and open out into a square arm, thereby presenting a much greater resistance to syphonage.

(2.) *Waste-pipes.*—The waste-pipe from a well-arranged slop sink should be made of drawn lead, 3 inches in diameter, carried outside the wall of the house. If it is connected with the soil-pipe the out-go

bend should be ventilated by a special pipe to prevent syphonage, but such ventilation may be dispensed with if the pipe is made to discharge into a ventilating intercepting trap.

All other waste-pipes, such as waste-pipes from scullery sinks, baths, etc., should be made to discharge into the open air on to a grating (Fig. 13), or into a ventilating intercepting trap, but in any case they should be thoroughly disconnected from any soil-pipe or drain. Waste-pipes from scullery or pantry sinks should never be larger than $1\frac{1}{2}$ or 2 inches in diameter.

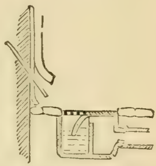


Fig. 13.—Waste-pipes discharging over grating and trap.

(3.) *Traps.*—That too much reliance has been placed by engineers and builders on the efficacy of traps for the exclusion of sewer-air, is now a well-established fact. Up till quite recently no adequate provision was made for drain or sewer ventilation, and the consequence was that mechanical ingenuity became taxed to the uttermost to prevent the pent-up sewer-gases from forcing their way through the terminals of drains, which for the most part were situated inside houses. When hot water is poured down a drain, or when a sewer becomes suddenly charged with a large volume of water, as after a heavy fall of rain, the forces which are brought to bear within the sewer are far greater than the resisting power of any trap, and the displaced gases make their escape often at points where they are the most dangerous. There are few traps whose resisting power exceeds that of a column of water an inch and a half in height; indeed, the greater number of them, as, for example, common bell-traps, have only a resisting power of about one-quarter of an inch. Besides, it should be remembered that the water in an otherwise very efficient trap will absorb sewer-gas on one

side and discharge it but little changed on the other. All traps, therefore, should be regarded as at the best useful auxiliaries only, for in no case will they afford protection against the escape of foul air if proper ventilation be neglected. Some traps, such as the common bell-trap, are worse than useless, because they are readily removed, often forgotten to be replaced, and are easily broken. Many traps, too, and especially those which are supposed to protect the terminals of drains in cellars or basements, are practically useless, because the water in them speedily evaporates and is seldom renewed.

Although there is an infinite variety of traps, the most useful of them are constructed on the syphon principle. Syphon traps may be described as curved tubes, in which it is necessary that the bend should be sufficient to permit of some portion of the roof of the pipe to be below the water level. What is called the *seal* of the trap is the difference between the surface of the water and the depression at this point (Fig. 14).

Traps constructed on what is called the mid-feather principle have one or more partitions dipping into the water between the entrance and outlet (Figs. 13 and 16), and the dip of the partition into the water represents the depth of the seal. The objectionable D-traps are of this description, and the common bell-trap, with its various modifications, belongs to the same category.

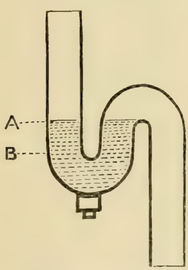


Fig. 14.—S-trap with screw. A, B, Water seal.

The special features of a good trap may be summarised as follows :—A comparatively small internal surface and contents; every portion of the surface washed by every flush ; no angles, edges, or corners ; and a good water seal yet easily cleared.

Water-closet traps should have at least a 2-inch water seal, and the traps on waste-pipes may vary in depth of dip from 2 to 6 inches. These latter should be of the S or half S pattern, or of the kind known as the anti-D trap, but whichever form is used, the lower bend of the trap should be fitted with a movable screw-cap for cleansing purposes (Fig. 14). No trap to be efficient should have a water seal less than $1\frac{1}{2}$ inch deep. All bath and lavatory pipes should be trapped in this way, even when they do discharge on to open gratings, to prevent the entrance of cold or foul air.

Fig. 15 represents a mud intercepting trap, containing a small bucket which by means of a handle can be readily lifted out. Traps of this description are very useful to receive the waste-pipes of sinks, etc., and should be regularly cleaned out, and for this purpose it is preferable that they should be round instead of square.

Fig. 16 is an illustration of a simple gully or yard trap to receive surface water or rain-water pipes, which should never discharge directly into the house drains.

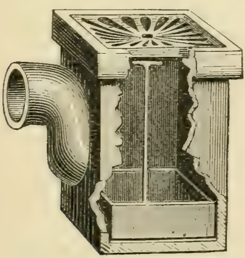


Fig. 15.

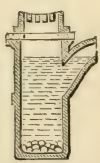


Fig. 16.—Simple Gully Trap.

Of what are called ventilating intercepting traps, or "sewer-air" interceptors, there is a great variety, but all of them are intended to furnish a complete air disconnection between the pipe or drain and the sewer. The air inlet

of the trap provides for a constant current of fresh air entering the drain and passing up the ventilated soil-pipe or other ventilating pipe. Fig. 17 is an illustration of this form of trap, and where a disconnecting man-hole is not provided, the model bye-laws of the Local Government Board enjoin that, as regards new houses, a trap of this description should be used to intercept all house drains from the sewer. As a rule, the trap should contract at its bend to a smaller sectional area than the drain, a 4-inch trap, for example, being sufficient for a 6-inch drain. There should be a fall of at least an inch from the discharging end of the drain to the level of the water in the trap, while the inlet should be vertical or nearly so, and the outlet sloped at an angle of about 45°. The trap should have a foot or pedestal to prevent its slipping from position; and in order to secure more effectual flushing, the drain should have a slightly greater fall towards its junction with the trap. The air inlet to the syphon is

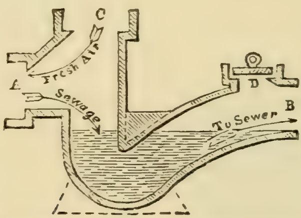


Fig. 17.—A. Socket for house drain. B. Connection with outfall drain. C. Socket for fresh air inlet pipe. D. Cap for clearing purposes.

carried by a vertical pipe to the surface, where it is covered with a grating, or if it is in a position to receive dust or pebbles it should be ventilated by means of a small side chamber, or by a 4-inch pipe carried up some short distance along an adjoining wall. It is always preferable, however, to construct an inspection man-hole in connection with any trap of this description.

(4.) *House drains.*—Unless absolutely necessary, no drain which receives sewage should traverse the basement of a house; and when it is necessary, as when houses are joined together in streets or squares, every such drain should be made absolutely air and water tight. Pipes of glazed earthenware 2 feet in length are generally used for the purpose, and should not be less than 4 inches in diameter. They should be laid on a bed of concrete made with ground lime or cement, securely jointed with cement, and covered with concrete. They should also be provided with full means of inspection at either side of the basement. When they pass through foundation walls it is advisable that relieving arches should be turned over them, because it often happens that they become broken by settlements. The pipes are laid with the sockets pointing to the soil-pipe or head of the drain, and unless special joints are used, such as Stanford's, or what is called the *tongue* joint, great care must be taken that no cement projects into the drain when cement is used for jointing.

Cast-iron pipes of the weight and description constantly made for water mains are now being largely used for house drainage, and though the pipes themselves are more expensive than glazed earthenware pipes, there is much less jointing required. All the safe-guards as regards a bed of concrete may be dispensed with, and they may be laid at much shallower depths. Indeed, in America, instead of being carried under the basement, they are often slung on to the beams supporting the ground floor, so that they are always exposed to view. The pipes are cast in 9 feet, 6 feet, and 3 feet lengths, and are jointed together with tarred yarn and molten lead. They should be coated outside and inside with Dr. Angus Smith's composition to prevent corrosion. Cast-iron bends and connections of various shapes and sizes, as may be required, and cast-iron man-holes with cast-iron intercepting traps,

can all be procured for the complete requirements of house drainage, and the pipes can be obtained of 4, 5, and 6 inches diameter. Although the initial expense may be somewhat greater, there can be no doubt that this system affords a far greater guarantee of sanitary safety than the ordinary system of drainage by glazed earthenware pipes. Junctions to soil-pipes can be made more secure, and there is no possibility of leakage in any other part of the track.

If drainage is required to dry the subsoil, a drain with open joints surrounded by gravel should be laid across the basement or round the house, but such drain should never be connected with the house drain unless it is safely disconnected by a ventilating intercepting trap or man-hole. Cellar drains should also be disconnected in the same way, and preferably into an open area.

For average-sized houses the diameter of the house drains should not exceed 4 inches, and pipes of 6 inches diameter are found to be quite capacious enough for large houses or mansions; but for very large establishments or groups of buildings, an outfall drain of 9 inches diameter may be required. As regards gradient, that of a 4-inch drain should not be less than 1 in 40; of a 6-inch, 1 in 60; and of a 9-inch, 1 in 90,—yielding in each case a flow of between 3 and 4 feet per second.

Drains should always be laid in straight lines, and where a bend is necessary it should be effected by a pipe of proper curve. In connecting branch drains with main drains splayed junction pipes are used, and in connecting a smaller with a larger drain directly, taper-shaped or "reducing" pipes are employed.

When drains pass across areas, yards, or open courts near the surface, access openings are very useful for purposes of inspection. They should be provided with air-tight covers, but should never be fixed inside houses, lest the covers should be negligently left open.

Instead of the simple ventilating intercepting trap (Fig. 17), which may be deemed sufficient to disconnect the drains of small houses, it is necessary that for larger houses a disconnecting chamber (Figs. 18 and 19) should be provided at the point of junction of the several drains with the outfall drain. This chamber should be built of glazed bricks set in cement, and on a concrete foundation. The main house drain is continued through the floor of the

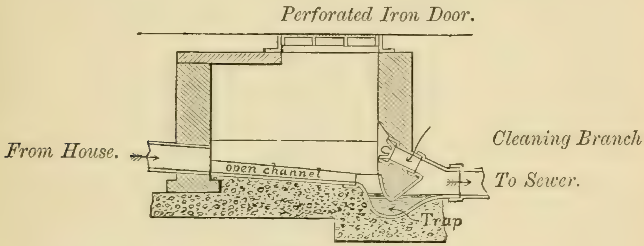


Fig. 18.

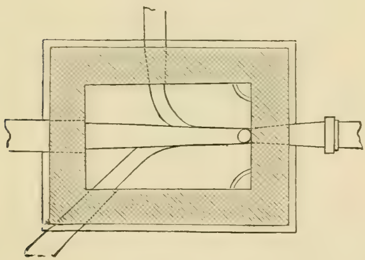


Fig 19.

chamber by means of a glazed channel or white porcelain pipe, and from this the floor of the chamber, which should also be cemented, slopes upwards towards the sides of the chamber. Any other drains which converge at this point are connected with the main channel pipe by other channel pipes (Fig. 19), which should be suitably curved to permit of an easy flow. If the drain from the

house is a 6-inch drain, the main channel tapers and discharges into a 4-inch syphon trap, provided with a cleansing branch or "raking arm," as it is called, to permit of the removal of any obstruction on the sewer side of the trap, but which is closed by an air-tight cap or plug when it is not used. If the chamber is situated in a position free from dirt and away from traffic, it may be ventilated by a perforated iron door or grating, but otherwise the chamber should be closed by an air-tight cover, and ventilated either by a 4-inch pipe or through a small adjoining chamber or dirt-box covered with a grating, but in any case the ventilating opening should be in the corner of the chamber opposite the entrance of the house drain.

In carrying out a proper system of drainage for large houses or public institutions, inspection man-holes with close covers should be provided at all points where there are important junctions, or where the main drain changes its course. It may here be noted, too, that in laying down a new system of drainage for old houses, all old drains under or near the houses should be taken up, and any polluted soil removed. It should also be made a rule never to lay a new drain in an old culvert, as is sometimes done, nor connect a new drain with an old outfall drain, unless such drain is found to be in fairly good condition, and proper disconnection be made by means of a ventilated man-hole and intercepting trap. Where new drains are required, old drains should be taken up.

Before they are covered in, all new drains should be tested by the hydraulic test, to discover whether there is any leakage at the joints. This can be readily done by stopping up the lower end of the drain, and either filling from the soil-pipe or from a bent junction fitted temporarily into the head of the drain. (For further remarks on drain testing, see chapter on Dwellings.)

If the gradient of the house drains is low, and deposit liable to occur, it is always advisable to place a self-acting syphon flush-tank as near the head of the drain as possible. This may be filled either by the waste-pipe from scullery sink or the waste-pipe from a bath, if that is regularly used; or it may be filled at regular intervals, say once a week, from a water-tap specially fixed for the purpose. Fig. 20 is an illustration of a grease interceptor which is intended to receive kitchen waste water, and makes a very efficient self-acting flush-tank for small

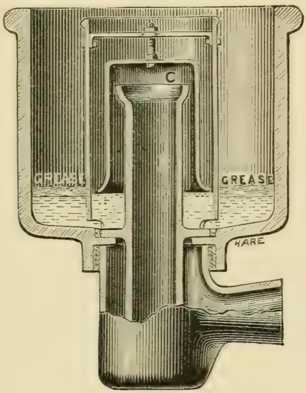


Fig. 20.

houses with 4-inch drains. Such a tank need only hold 12 or 15 gallons. But for larger houses, or public institutions, it is preferable to make the scullery sink pipe discharge into a large gully trap covered with a grating, which should be flushed by an automatic flush tank to hold 30 gallons at least and supplied by water from a tap. The rush of water into the gully trap each time the tank discharges effectually clears out all the fat and grease which are otherwise liable to accumulate.

Whether arrangements are required for flushing or not,

the house drains so constructed, ventilated, and intercepted may be connected either with a public sewer, or in country and suburban districts, where there are no public sewers, they may discharge into a cesspool. In the former case, where pipe-sewers are laid, they should be connected by proper splayed junctions, or if they discharge into brick sewers they should curve in a downward direction sloping towards the fall of the sewer, and discharge above the sewage level. When the sewer is liable to flooding, it is sometimes deemed necessary to provide a tidal valve between the sewer and drain, but this should always be avoided if possible.

Where a *cesspool* is required to receive the sewage of a country house provided with water-closets, it should be situated at a safe distance from the building, made perfectly water-tight, and be abundantly ventilated. It is also of the utmost importance that a syphon trap with ventilated man-hole should be provided in the course of the drain. The plan of construction should be on the liquid-manure tank principle, the walls being of brick-work set in cement, surrounded by a clay puddle, and lined inside with a coating of cement. Both roof and bottom should be arched, the roof provided with a man-hole, and the bottom built with a fall towards one end, where a chain pump could be fixed. The depth should not exceed 6 or 7 feet, otherwise the increased hydrostatic pressure would necessitate expensive walling. To separate the solids from the liquids a galvanised iron wire diaphragm or grating should divide the tank into two parts. All cesspools should be regularly and frequently cleaned out, and according to the model bye-laws of the Local Government Board, they should be at least 50 feet from any dwelling and 60 feet from any well. If the cesspool is situated in a field or orchard some distance from the house, the liquid contents can

frequently be got rid of by constructing an overflow-pipe leading into sub-irrigation drains, either with or without a flush-tank. (See next Chapter.)

3. PUBLIC SEWERS.—(1.) *Construction.*—Public sewers are constructed on what is called the separate, or that known as the combined, system. In the separate system the surface and subsoil water is excluded as far as practicable, and removed by separate channels. In the combined system, on the other hand, the sewers are constructed of a capacity to receive and carry off the rainfall as well as the sewage and waste water. In London the capacity of the sewers which convey the sewage to the outfall is calculated on the assumption that the sewage averages $31\frac{1}{4}$ gallons per head of the population in the twenty-four hours, and that the greatest average rainfall is $\frac{1}{4}$ inch during the same period. What are called storm over-flows, which discharge at various points into the river, are also required to relieve the sewers during times of excessive rainfall.

For average-sized towns there is no doubt that the separate system possesses several important advantages over the combined system; and indeed, in many of them, such as Dover, Ely, Gloucester, etc., the old drain-sewers have been made available to carry off the subsoil and storm-water, while pipe-sewers are found to be sufficient for the most part to convey the sewage proper. The advantages of the separate system, especially when the sewage has to be pumped at the outfall for irrigation purposes, are obvious. The volume of sewage is very much smaller; there is much less fluctuation in the daily and seasonal flow, and therefore greater uniformity in the composition of the sewage; the sewers are kept cleaner, and there is much less liability to the formation of deposit. On the other hand, the separate system does

not ensure the important hygienic condition of drying the subsoil, unless old drains can be utilised for that purpose or separate drains are laid down, or unless subsoil-pipes are conjoined with sewer-pipes, as in the system devised by Messrs. Brook and Son of Huddersfield. This consists of flat-bottomed ⌓-shaped under-pipes for the subsoil water, and of circular over-pipes supported on cradles connected with the under-pipes for the conveyance of the sewage.

Pipe-sewers are made of various sizes, from 9 inches up to 18 inches in diameter, and the same rules apply as regards laying and junctions which have already been described in connection with house drains. Sewers of larger dimensions are generally made of glazed bricks laid in cement, and the bricks are moulded to suit the curve of the sewer, which should be an egg-shaped oval, with the small end, or invert, downwards. This form of sewer possesses the great advantage that there is greater depth of sewage, less friction, and less liability to deposit than any other form of sewer; although for outfall sewers, when the volume of sewage is large, most engineers prefer the circular form, on account of its greater cheapness and strength.

The inverts of egg-shaped sewers are now generally constructed of glazed stoneware blocks, which are sometimes made hollow to drain off the subsoil water during the construction of the sewer; but in order to prevent fracture from the weight of the brickwork built over them, they are filled in with concrete. All sewers, whether they are pipe-sewers or constructed of brick, should be laid on a bed of concrete, and have their lower segments imbedded in concrete. Small sewers under 3 feet in diameter may be constructed of $4\frac{1}{2}$ brickwork, but for larger sewers 9-inch brickwork is required, and for greater strength two courses of bricks may be necessary.

No sewers or drains should join main sewers at right angles or opposite the entrance of others. They should always join in the direction of the flow of the sewage. They should also be laid in straight lines from point to point, and when curves are necessary the radius of the curve should not be less than ten times the sectional area of the sewer. At all important junctions and changes in direction, man-holes or side entrances should be provided for inspection. No catch-pits should be constructed in the bottom of sewers, because the foul excretal matters retained with *detritus* increase the putridity of the sewage and the evolution of highly offensive effluvia. All mud and road *detritus* should be intercepted by gully traps (Fig. 16), into which the gutters and channels on both sides of the roadway discharge, and which should be cleaned out at regular intervals.

The fall or gradient of public sewers should be sufficient to ensure a velocity of not less than 1 foot, and not more than $4\frac{1}{2}$ feet per second, — the minimum fall ranging between 1 in 250 to 1 in 750; though in some flat, low-lying towns, such as Southport, the gradient is sometimes as low as 1 in 5000, but then special arrangements must be made for flushing.

Where the gradients are steep, what are called tumbling bays (Fig. 21) become necessary to prevent the wear and tear of the sewers by the scouring action of the rush of sewage down a steep incline. These tumbling bays are provided with a man-hole and ventilating chamber, while the upper section of the sewer is intercepted at its outfall by a flap-valve which prevents the entrance of sewer gas. In engineering language this is termed "ramping" a sewer.

In large towns with hilly, undulating surfaces, intercepting sewers are constructed along the valley lines to receive the tributary sewers from the more elevated parts, and so divide the town into manageable drainage areas.

These intercepting sewers are also especially advantageous at many seaside places, in order that the sewage may be discharged at such a distance from the town as to prevent nuisance on the foreshore.

What is called *Shone's Hydro-Pneumatic System* enables

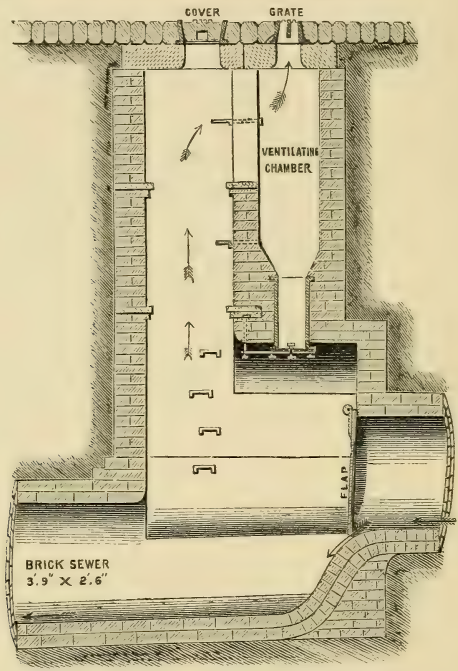


Fig 21.—Man-hole, Tumbling Bay, and Double Ventilating Arrangement. (After RAWLINSON.)

engineers to overcome many of the difficulties with which they have to contend when a sufficient fall cannot be obtained, or when deep cuttings have to be faced. By means of *sewage ejectors*, which are worked by compressed air, the sewage is forced along iron pipes from one or more collecting tanks, either to the outfall or to

any desirable level. The system has been for some time in successful operation at Eastbourne, Henley, Wrexham, Warrington, and other towns, and has also been made available for the efficient drainage of the Houses of Parliament and other large buildings.

When a sewer has to be carried across a river, an inverted syphon constructed of iron pipes becomes necessary, and inspection man-holes are required at either end. Unless the current is of sufficient velocity to carry all solid matters with it, special arrangements must be made to keep the syphon clear, either by straining the sewage or by periodic flushing, and in order to ventilate the syphon efficiently, a ventilating pipe should be connected with the descending arm. Syphons are also used to convey sewage across valleys when the sewer is too low to permit of bridging.

As has already been pointed out, the *velocity of flow* in sewers should never be less than 1 foot nor more than $4\frac{1}{2}$ feet per second. In the former case deposits are apt to occur, and in the latter, the friction is liable to wear out the invert. Large sewers, with a proportionate volume of sewage, require a less gradient than smaller sewers. To estimate the volume of sewage discharging from sewers the following formula is generally used:—

Let V = Velocity in feet per minute.

„ D = Hydraulic mean depth.

„ F = Fall in feet per mile.

„ A = Sectional area of current of the fluid.

Then $V = 55 \times (\sqrt{D \times 2\ F})$

And VA = Discharge in cubic feet per minute.

D, the hydraulic mean depth, is one-fourth of the diameter if the pipes are circular; in all other cases it is the sectional area of the current of sewage, divided by the wetted perimeter, or, in other words, that part of the circumference of the pipe which is in contact with the

stream. F, the fall in feet per mile, can be ascertained by taking the levels between man-holes, and the distance from man-hole to man-hole (see Appendix).

As regards the outfall, the arrangements will depend upon whether the sewage is to be treated chemically or purified by irrigation; whether it is necessary to pump it; or whether it is intended to discharge it direct into a tidal river or the sea without treatment. If pumping is required there must be a storage tank or reservoir at the pumping station; or if, on the other hand, the sewage is treated chemically, a duplicate series of settling tanks must be constructed, varying in size and number according to the volume of sewage. When the sewage of an inland town can be purified by irrigation, and the town is of sufficient elevation to permit the sewage to flow on to the farm by gravitation, all that is required is simply to strain the sewage by means of strong iron screens; and unless the sewage is treated chemically before it is distributed over the land, settling tanks should be dispensed with, because they have the effect of greatly increasing the putridity of the sewage. The mouth of the outfall should, however, be protected by a flap-valve to prevent winds when they blow in that direction from sweeping back any sewer-gas towards the town. When towns discharge their sewage into tidal rivers, the reports of the Royal Commission on the discharge of the London sewage prove very clearly that the sewage may concentrate near the outfall, and constitute what they have termed a "sewage zone," oscillating backwards and forwards with the tides; and when spring tides give place to neap tides, the sewage may be carried up higher and higher above the outfall, and become a source of great nuisance to the inhabitants living on the banks of the river.

As regards seaboard towns, the sewage may under certain circumstances be discharged directly into the sea,

but the outfall must be at a point where there is no risk of the sewage being drifted by currents towards the foreshore. The sewer should also be carried far enough out so as to open in all states of the tide below the surface of the water, and the mouth should be protected by a tidal valve to prevent the inrush of sea-water as the tide rises. If the town is low-lying, it becomes necessary to construct either what is called an oval tank sewer, or, preferably, one or more storage reservoirs from which the sewage may be pumped or discharged at the fall of the tide. It is in respect to towns so situated that Shone's system becomes especially applicable.

(2.) *Ventilation of Sewers.*—In order to prevent concentration or stagnation of the gases which are largely given off by sewage, it becomes a matter of the utmost importance to provide a sufficient number of openings communicating with the sewers, to ensure free ventilation. As already pointed out, main sewers, with steep gradients, should have a man-hole, a tumbling bay, and ventilating arrangements at intervals according to the steepness of gradient (Fig. 20). For ordinary sewer ventilation, however, the man-hole cover without a side-chamber is generally utilised for ventilating purposes, or efficient ventilation can be secured by making a sufficient number of direct openings into the crown of the sewer, but in all these cases it is necessary to fix a dirt-box under the ventilating grating to intercept any solid matters which would otherwise fall into the sewer. At one time, it used to be the practice to place one or more trays containing charcoal in the man-hole to deodorise the sewer-air as it escapes, but this plan has been abandoned because it was found that the charcoal greatly impeded free ventilation, and was but a feeble deodorant. Various other devices have been tried from time to time to deodorise the offensive effluvia issuing from ventilators,

such as sulphurous acid gas obtained either from a concentrated solution of the gas or from potassic or sodic permanganate and sulphuric acid, but all such expedients are only palliatives and require constant attention. Another plan, which has been tried with varying success at Ealing and some other towns is the use of *sewer-gas destructors* which answer the purpose of ordinary lamp-posts. In these a large gas-burner is placed within the base of the shaft which communicates with the sewer, and the other arrangements are such that the organic matter contained in the sewer-air is consumed as it passes through the flame and up the shaft.

In cases where the sewer runs parallel with and close to the pavement, it is advisable to carry the ventilating shaft in a sloping direction to an open grating situated in the centre of the street, or to erect a ventilating pipe against the wall of an adjoining building. In narrow confined streets these ventilating shafts become especially necessary, because direct ventilation into the crown of the sewers under such circumstances is often attended with great nuisance. It should also be remembered that the foul effluvia given off by ventilators are frequently engendered by the catch-pits which are constructed below the ventilators to retain road-drift, but which retain excrementitious matter as well. As already pointed out, all such catch-pits should be done away with, and the ventilators be provided with dirt-boxes. Special attention should be given to the ventilation of the dead ends or terminals of sewers, either by ventilating gratings or ventilating shafts, because otherwise they form cul-de-sacs for the retention of sewer-air.

As regards the number and distribution of ventilating openings, it may be said generally that in addition to the terminals, the junctions of all branch sewers with main sewers should be ventilated, and according to

Rawlinson there should not be less than 18 fixed openings or 1 at intervals not greater than 100 yards, for each mile of main sewer. Much, however, will depend upon the character of the sewers. If the system of sewerage is new, and the drainage of all houses is intercepted from the sewers, many maintain, and with some show of reason, that only a few openings are required for the escape of displaced air at times of heavy rainfall, and that free ventilation under these conditions is not only unnecessary, but that it greatly conduces to putrefactive change in the sewage. But in all sewers some deposit forms on their sides, owing to the varying volume of sewage flowing through them, and this deposit, being alternately wet and dry, speedily decomposes, and parts with its putrefactive ferments not only to the sewage itself but to the sewer-air. Hence, the great object of ventilation is by means of numerous openings to so dilute the sewer-air as to render it innocuous and imperceptible to the senses. Some ventilators will act as inlets for fresh air, and others as outlets, according to the direction of the wind. There can be no doubt that direct ventilation, when properly carried out, is the most efficient, and if sewers are properly constructed in the first instance, and kept well flushed, there should be no nuisance from the ventilators; but where nuisance is found to exist, a ventilating pipe or shaft, carried up an adjoining wall, will be found sufficient to remedy the evil.

Main sewers, liable to be affected by the rise of tides or land floods, must be abundantly ventilated, in order that the sewer-air may not be forced back into the tributary sewers and drains. To provide for efficient ventilation under these circumstances, Drs. Parkes and Sanderson, in their report on the sanitary condition of Liverpool, recommended the erection of lofty shafts, with a sectional area at least half as great as that of the sewers. They

condemned the ventilating shafts in use at the date of the inquiry as being too narrow, and ascertained by experiment that the Archimedean screw ventilators, with which the shafts were supplied, only aided the extractive power by 20 per cent.

No water from manufactories of an elevated temperature should be allowed to enter sewers before being cooled, because it accelerates putrefactive changes in the sewage. Blowing off steam from boilers is also objectionable, and is prohibited by the Public Health (Amendment) Act.

(3.) *Flushing of Sewers.*—As offensive discharges of sewer-air are largely due to the formation of deposits, careful attention to systematic flushing is highly essential. In addition to special arrangements for the flushing of main sewers, there should also be a flushing chamber or self-acting syphon flush tank at the head of every branch sewer,—such chambers being flushed either from the mains, where there is a public water-supply, or in villages and suburban districts, where there is no such supply, by means of a water-cart. If the flushing is carried out from the mains, care should be taken that there is no intimate connection between these and the sewers. Main sewers are flushed by means of sluices or flushing-gates, which are used at various man-holes as required, and are made to fit the whole or part of the sectional area of the sewer. When these are placed in position they dam back the sewage in the sewer, and on being raised or removed, the rush of sewage effectually flushes a certain length of the sewer below. In large brick sewers, self-acting flood-gates are often used. These gates are hinged below their centre, so that the pressure of the sewage fixes the gate until it rises to a point above the hinge, where, on account of the greater pressure on the upper surface, the gate tilts and assumes a horizontal position, thereby liberating a huge volume of sewage. As the

sewage falls to its normal level, the flushing-gate tilts back into position, and so the self-acting flushing process goes on.

With a system of sewage properly constructed, well ventilated, and regularly flushed, the dangers arising from atmospheric pollution by sewer-gases is reduced to a minimum. Indeed, the amount of impurities in sewer-air under these conditions is so small as to be almost inappreciable to the senses; and it may be laid down as a rule, that whenever foul effluvia are given off, it is an indication that the sewer is insufficiently ventilated, imperfectly flushed, or that it has been badly constructed in the first instance.

Section II.—Conservancy Methods.

1. *The Privy or Midden System.*—This system, which formerly was general in most towns, and is still very common in rural and suburban districts, is open to the gravest objections unless special precautions as regards structural details are carried out. Leaky and fœtid cess-pits and large deep midden ash-pits are always a source of danger, even in rural districts. According to the well-known report of the late Mr. Netten Radcliffe to the Local Government Board on Filth-Nuisances, the only kinds of midden-privies which were found to answer sanitary requirements fairly well were the improved midden-steads of Hull and Glasgow, which were constructed so as not to be under the ground level, but even these could not be scavenged without creating nuisance. Other schemes, intended to diminish the offensiveness of large midden-steads, as observed in Manchester, Salford, Nottingham, and elsewhere, were all found to have practically failed. In Manchester, where many of them were drained into the sewers, it was discovered that the sewers were becoming gradually choked up with sediment.

Where privies are still tolerated they should be constructed in accordance with the model bye-laws of the Local Government Board. These enjoin that no privy should be nearer than 6 feet to any dwelling, nor 40 feet to any well, and it should be so situated as to be readily accessible and to admit of scavenging without the necessity of carrying the contents through any dwelling or place of business. The privy must be well ventilated, and that part of the floor which is not under the seat must be not less than 6 inches above the ground level and with a slope towards the door of half-an-inch to the foot. The floor itself must be paved with hard tiles or other non-absorbent material, and the capacity of the receptacle or space under the seat must not exceed 8 cubic feet. The floor of this receptacle must be in every part 3 inches above the ground level, and both this and the sides must be constructed of impermeable materials,—9-inch brick-work set in cement or asphalted, while the sides may be flagged or cemented. The seat should be hinged to allow the contents to be removed, or other means of access either at the back or side of the privy be provided. In order to keep the contents dry, it is necessary that sifted ashes or dry earth should be used.

When such structural details as these are carried out, there is of course no danger of percolation into the soil, but the difficulty always is to procure a sufficient quantity of sifted ashes or dry earth, or if procurable to get people to use them. This is the great difficulty which is always encountered in rural districts, unless the ash-pit, which should also be above the ground level, is connected with the privy. In towns there can be no doubt that some form of the pail system is the only safe system where water-closets are not in general use.

2. *The Pail System.*—In this system the excreta are received into movable receptacles, and according to the

model bye-laws of the Local Government the construction of the closet should be the same as that which has been described for a properly constructed privy.

In order to carry out this system in the most efficient manner, two pails are required for each closet, one to receive the excreta, and the other the ashes and house-refuse. The excrement pail may be either a wooden pail or tub, as used at Rochdale, Nottingham, and Halifax; or it may be of metal, such as that used in Manchester, Leeds, and Birmingham. In either case it is requisite that it should be round, so that it can be easily cleaned, and as regards capacity and convenience for removal, its cubic contents should not exceed 10 gallons. If of wood it should be tarred or creosoted, and if of metal it should be made of galvanised iron. All pails should be provided with tight-fitting lids, so that they can be carted away without creating nuisance. When one pail is removed, another, which has been thoroughly cleaned after having been emptied at the depôt, should be left in its stead.

The ash-pail should be somewhat larger than the excrement pail, and may be either a rectangular box of handy dimensions, a tub, or a galvanised pail.

In the Goux system, as carried out at Halifax, the tubs are lined with some dry absorbent material, such as chaff, straw, shoddy fluff, hay, dry ferns, or any kind of animal and vegetable matter which is useless for other purposes. The materials are pressed close to the bottom and sides of the tub by means of a mould, which is afterwards withdrawn. A separate bin must be used for the ashes and house refuse; but urine may be emptied into the tub, and is supposed to be absorbed by the lining, the excreta remaining tolerably dry. The tub is removed once or twice a week, according to circumstances.

In Birmingham, Leicester, and other large towns, the

pails are used for the excreta alone, while at Nottingham the ashes and other dry household refuse are added. In Manchester the ashes are thrown upon a sifter, which is so arranged that the fine ashes fall into the pails.

In what is called the *dry earth system,* of which Moule's earth closet may be regarded as the type, the receptacle may either be fixed or movable. Moule's closet is made self-acting, and after each stool the requisite quantity of dry earth, about 1½ lb., is discharged into the receptacle. The earth should be carefully dried and sifted; and as regards soils to be used, rich garden mould is found to be the most absorbent, and sand the least.

Amongst other deodorants or absorbents which have been used for pail closets may be mentioned peat, or sea-weed charcoal, which can be recarbonised in a retort, and the carbon used again; a mixture of soot and salt; deodorant powders used with sawdust, etc.; but all these methods are too expensive for general use, and without proper care and supervision they possess no special advantage over the ordinary pail system. Indeed, as regards all populous localities, it may be said that the attempts to economise in town-sewering and scavenging by removing human excreta separately has been a failure, and local costs, as well as local nuisances, have been increased.

Section III.—Lieurnur's and other Continental Systems.

These need only require brief mention. Captain Lieurnur's system may be described as consisting of air-tight iron tanks situated under the streets, which are connected by iron pipes with the closets in the houses. By means of a powerful air-pump, worked by steam, the sewage is sucked along the pipes to these central tanks, and is afterwards converted into *poudrette.* Only a little

water is used in the closets. The system has been tried in Amsterdam, Leyden, and elsewhere; but, owing in great measure to its original cost, it has not met with much acceptance. Moreover, it appears to be radically defective in principle, because it is evident that the pipes must become clogged up sooner or later with fœcal matter, and indeed this result is not at all unusual.

The *fosses permanentes* of Paris, Brussels, and other continental towns are huge pits, placed generally under courtyards. They are lined with cement, so as to render them impervious, and are usually ventilated by shafts rising some feet above the roofs of the houses. The contents are removed three or four times during the course of the year by air-tight carts (*tonneaux*), from which the air is exhausted previous to filling, so that the sewage is forced into them through a hose by atmospheric pressure. The closets in connection with the cesspools are almost invariably in a filthy state, from the habit of standing on the seat, which appears to be prevalent in private houses as well as in public places.

The system known as *fosses mobiles* is now adopted in many continental towns, and is a great improvement on the system of *fosses permanentes.* The *fosse mobile* is a closed tub placed on a stand with wheels, and connected by a descent-pipe with the different closets or *faïences* of a house. When filled it is replaced by another of the same construction. The *abfuhrtonnen* of the Germans are of a similar description, but in many of the larger towns the bucket or pail under the privy seat is used (Berlin, Leipsic, etc.)

Section IV.—Methods best suited for Rural Districts.

In villages where the scavenging is undertaken by the Sanitary Authority, it is just as essential that some

uniform scheme of excrement-disposal should be adopted as in towns; but in the great majority of country villages provided with sufficient garden space, public scavenging is not necessary, because the solid refuse can generally be safely disposed of in the gardens. The kind of alterations, therefore, which may be required to remove privy nuisance, will depend very much upon existing arrangements. If, for example, the privy abuts against the house, or is not very far from a well, it should either be removed altogether, or be converted into an earth or ash closet, and be provided with a box or pail to receive the excreta. Inside a house, the only kind of closet which can be used without risk to health must be a properly constructed water-closet or a dry closet of an approved pattern; but in either case the closet must be detached from any living or sleeping room, and be properly ventilated. In country villages, however, the closet accommodation, except in a few of the better-class houses, is situated outside, and is of every conceivable description. In the older villages it is sometimes represented by a rough wooden erection, with a hole dug in the ground to receive the excreta; or more frequently by a sentry-box-looking structure, stuck somewhere near the far end of the garden, and with a stinking leaky cesspit behind. In more modern villages, however, the privy and ash-pit or midden-stead are found combined; but as a rule the ash-pit is large and deep, leaky and uncovered, so that at all times it is more or less of a nuisance. Then, again, in the few best-class houses provided with water-closets, it is generally found that the sanitary arrangements and appliances are of the most defective description, and that the closet discharges either into a covered cesspool, from which any gases generated can escape only into the house, or into a village-drain which was not constructed to receive

excremental filth. Such, briefly, are some of the more common varieties of closet-accommodation to be met with in rural districts, and it need hardly be said that the structural defects connected with them are a constant source of nuisance and risk to health. How, then, are these defects to be remedied, legally, in the first place, and with a due regard at all times to efficiency and cost? The privies or closets are generally so low in the roof that to raise the floor above the ground level, it would be necessary in most cases to raise the roof, which would practically mean entire reconstruction; and unless the closet itself is in a dilapidated condition, this may not be necessary. All that the law requires is that any nuisance must be abated, and in my own district the rural sanitary inspectors are supplied with the following instructions, which are forwarded along with any notices which are issued for the abatement of privy nuisance. The instructions are illustrated by lithographs of the various alterations which are recommended to suit different circumstances, and whatever kinds of alteration are deemed necessary are carried out to the satisfaction of the inspectors of the several districts;—

Any common privy vault or cesspit, or any deep midden ash-pit, the contents of which are in a wet and sloppy condition, is always a source of danger to health.

To prevent nuisance it is necessary that the bottom of the privy or ash-pit should not be below the ground level.

Any common privy or deep midden ash-pit can be readily altered, so as to prevent nuisance, by cleaning out the privy vault, cesspit, or deep midden ash-pit, and filling up with sound earth to the level of the ground, and properly paved.

The closet, if in proper repair, may then be converted into a pail closet, or a dry privy with fixed receptacle below seat, or ash-pit midden.

(1.) To convert it into a pail closet, the floor beneath the seat should be paved with flat brick laid in cement, the seat should be hinged in order that dry earth or sifted ashes may be thrown

into the pail without dirtying the seat, and the pail may be removed from time to time by lifting it out from under the hinged seat, or by providing a hinged opening of sufficient size either at the back or side of the closet. The kind of pail to be used should be a proper closet pail, with rim, which should come close up under the seat, and not a common household galvanised iron pail.

(2.) If a pail closet is objected to, the privy can be converted into a dry closet as above, but an opening, either at the side or back, with hinged or sliding door, must be provided through which the contents can be scraped out, and it is also necessary that the riser should be constructed either of a slate slab or brick laid in cement. In order to keep the contents dry, sifted ashes or dry earth should be thrown in from time to time as required. This kind of closet is not recommended if near a dwelling-house or well.

For this kind of privy closet as well as for the pail closet it is necessary that a small box should be kept in the closet to contain the sifted ashes or dry earth, and that a trowel or other convenient form of scoop should be provided.

(3.) To convert a common privy or deep midden ash-pit into a dry midden ash-pit, after cleaning out and filling in with sound earth, the bottom of the ash-pit and under the seat as far as the riser should be paved with flat brick laid in cement; the riser should be sloped and consist of a slate slab or bricks laid in cement; the dimensions, as far as possible, should not exceed those indicated on the plan; and it is absolutely necessary that the ash-pit should be at the back of the seat and not at the side. In many cases it is further necessary to enlarge the opening at back to almost the same width as the closet, and raise the lintel and seat so that the flooring shall not be below the ground level. A sloping cover, made either of tarred wood or corrugated iron, should be hooked on to back of closet to keep out wet, and it should be left open at both ends to secure free ventilation. This kind of closet, however, is not recommended if near a dwelling-house or well,—the only safe kind of dry closet in such a situation being the pail closet.

From these instructions it will be seen that a considerable amount of latitude may be safely conceded in respect to the methods by which nuisances connected with closet accommodation in rural districts can be removed. In villages, however, in which public scavenging is considered necessary, or in low-lying villages in which there is considerable risk of well-pollution, the only

suitable kind of closet is the pail closet. It recommends itself, too, on the score of cheapness, and often renders it unnecessary to remove the closet if near a house or well. As regards alterations for an ash-pit midden, it is very essential that the opening at the back of the seat should be wide enough to permit the covering of the excreta at all times with ashes; all corners should be avoided as much as possible, and in order to facilitate removal of the contents a door reaching to the floor level should be provided either at the side or back. In rural districts provided with urban powers, the kind of closet accommodation to be provided for new houses should be on the lines laid down in the model bye-laws of the Local Government Board as already described. Above all, it is highly essential that special attention should be given to the closet-accommodation of country schools. This should always be constructed on the pail or dry earth system, unless in villages where there is a water-supply, and where a proper system of drainage has been carried out. Under these circumstances trough closets will be found to answer best, not only on account of their cleanliness, but because they do away with all the trouble and expense of scavenging.

SECTION V.—PUBLIC SCAVENGING.

Except it be in small scattered communities, and perhaps purely agricultural villages, it may be laid down as a rule that no semblance of local cleanliness can be maintained unless the scavenging, as well as the sewerage, be undertaken by the Sanitary Authorities: for, in proportion as dwellings become aggregated, and populations increase, it becomes more and more difficult for individual householders to dispose of their refuse separately. Fortunately, in the great majority of agricultural villages there

is sufficient garden space attached to the houses to permit at all events of the safe disposal of the solid refuse on the premises without creating nuisance, or for exceptional cases there need be little difficulty in arranging for its disposal on some closely adjacent land. Arrangements, for example, may generally be made with some neighbouring farmer, or, as Mr. Haviland has suggested, any exceptional difficulties which may arise from want of sufficient garden space might be overcome if Sanitary Authorities were to provide a spare corner of ground, known as "the muck acre," to which householders could remove their solid refuse. But whenever in any village or town these difficulties are ascertained to be at all common, it then becomes the duty of the Sanitary Authority of the district to undertake the efficient scavenging of premises, and in case of refusal or neglect, they can be compelled to do so by order of the Local Government Board. In any case, however, the Sanitary Authority is virtually responsible for the cleanliness of its district, either by enforcing the provisions of the Public Health Act for the prevention of nuisance arising from filth-accumulation on individual premises in places to which scavenging does not extend, or by systematically preventing the occurrence of nuisance in places where public scavenging has been introduced.

As regards the general details of public scavenging, much will depend upon local circumstances, and upon the method of excretal removal which may be found to prevail in any particular town. Where the old-fashioned midden system is still allowed to be carried on, the house-refuse is mixed with the excreta, and both are carted away together. In the majority of towns, however, the ashes and other solid house-refuse must be collected and removed by a separate system, which necessitates the use of dust-pails or bins, and the daily or frequent visit of

the scavenger's cart. For dwellings occupied by single families the dust-box or pail answers very well, it being large enough to contain the dry refuse collected during the twenty-four hours; and as it is emptied into the scavenger's cart at a stated time daily, any accumulation about the premises is prevented. But in crowded parts, where families live in separate tenements, the whole of the ashes and dry refuse is usually, in the first instance, emptied into a common dust-bin, and afterwards carted away when the bin becomes full. In this case it is necessary that the bin should be roofed in, in order to keep the contents dry, and that it should be well ventilated. No slops or excrement should be allowed to be thrown into it, because the former excite fermentation in the vegetable and animal matters contained in the refuse, and the latter renders the contents offensive. It need scarcely be added that, in a sanitary point of view, dust-bins or ash-pits should be frequently and regularly emptied.

One very important branch of scavenging in urban districts is directed to the cleaning of streets and back courts, many of which are so badly constructed that it is next to impossible to prevent filth-accumulations. Gutters are often so unevenly laid, that after rain or flushing there are small stagnant pools to be seen throughout their whole extent. The surfaces of macadamised streets, again, are being constantly pulverised, and give off clouds of dust containing large quantities of decomposing animal and vegetable matter in dry weather, or are covered with liquid mud when it is wet; while paved streets present numerous interstices, which cannot be efficiently cleaned out even when scrubbing-machines and flushing are both used. There is no doubt, therefore, that the new plan of street construction which has lately been introduced into some parts of London and other large towns, whether it be wood-pavement or asphalt,

and preferably the former, will not only prove to be economical in many ways, but will also be productive of great sanitary advantages. Tar-asphalt, if properly laid, is especially applicable to side paths, back courts, and narrow streets, where the traffic is inconsiderable, because it is cheap, durable, non-absorbent, and washable.

In water-closeted towns, where only the dry ashes and house refuse have to be dealt with, these may be carted away to shoots, but in large towns the difficulties attending this method of disposal have become so enormous that "Destructors" or "Cremators" are now used to a large extent to burn the refuse. Another method of treatment, which has been recently devised, is carried out by the Refuse Disposal Company at Chelsea, in which the refuse is sorted by machinery. Each cart-load is tipped into a revolving screen, and from this point the great bulk of the material is separated mechanically. The cinders and fine coal are used to raise steam to drive the machinery; the smaller ashes are made into a black fuel; the paper and rags are manufactured into paper on the premises; bones, glass, pieces of iron, etc., are separated and sold; the vegetable matter and refuse are ground up with the fine dust, and are available for the manufacture of manure; and the whole process is carried on inoffensively. But in large towns such as Warrington, Birmingham, Rochdale, Leeds, etc., where the pail system still prevails, a more complicated method of treatment becomes necessary, and this may be briefly described as follows:—

(1.) *Ashes, etc., collected in ash-tubs.*—These are discharged at the ground-level of the depôt, and lifted by an elevator and cast into an automatic cinder-screen, which separates the material into two portions, viz. fine ash and coarser substances. The fine ash is discharged at a point sufficiently high that it can be shot into a cart without

labour, and afterwards removed and mixed with such portion of the pail-contents as will furnish a manure sufficient to satisfy any local demand. The coarser materials are discharged into the top of a furnace called a "Destructor," which is also self-feeding, and all that is required is to break up and remove the clinkers. The heat generated in the process of combustion passes under and through a multitubular boiler, and generates steam for furnishing the power required for working the whole machinery. The clinkers from the "Destructor" are passed into a mortar-mill, which reduces them to powder, and this is either sold as sand or mixed with lime to form an excellent and tenacious mortar.

(2.) *Street sweepings, including vegetable and animal refuse.*—This refuse, which consists mainly of sweepings from the markets and streets, is discharged on the ground-level, and raised by an elevator to a platform, and thence passed into a furnace called a "Carboniser," which converts all vegetable material into charcoal. The fuel required for heating this furnace consists of a portion of the sifted cinders from the ash-tubs. The charcoal produced is a powerful deodorant, and may be used for mixing with the pail-contents and sold as manure.

(3.) *Pail-contents.*—The bulk of these, which have not been mixed with fine ashes or charcoal, are emptied on the ground-level into a covered tank, and are conveyed by means of a chain-pump into an elevated air-tight store-tank. After having been mixed with a small portion of sulphuric acid to fix the ammonia, the thicker portion of the material settles to the bottom of the tank. The more liquid contents are drawn off into two "Evaporators," which are tall cast-iron cylinders, each containing near its lower end a drum-shaped heater, precisely resembling a multitubular steam-boiler. These cylinders are partially filled, and the heating-drums are covered with

the thin liquid; steam is introduced into the heating-drums, and the liquid becomes partially concentrated. When the contents have lost by evaporation the greater portion of their water, they are drawn off into a machine called a "Firman's Dryer," along with the thick portions of the pail-contents which have settled in the store-tank. This machine consists of a steam-jacketed horizontal cylinder, traversed by a steam-heated axis and by steam-heated revolving arms, and furnished with scrapers to keep the inner surface of the cylinder free from accumulations of dried excreta. The pail-contents are admitted into the "Dryer" at the consistency of thin mud, and after treatment this mud emerges as a dry powder resembling guano in appearance and quality, which fetches a good price as manure. All the steam generated is condensed, and the effluvia given off during the process is passed through the "Destructor" fire and destroyed.

Condemned butcher-meat and carcases, which constitute a considerable item of refuse in large towns, may either be steeped in disinfectants and afterwards sold to soap manufacturers, or they may be crushed in a mill called a "Devil," and afterwards treated in a Firman's "Dryer" which separates the fat, and reduces bone and other tissues to a fine fertilising powder.

Among the different forms of "Destructors" used for the burning of house refuse may be mentioned Fryer's "Destructor," Pickford's "Gourmand," and Nelson's "Beehive." In crowded localities, tall chimneys must be erected to carry off the smoke, and, to prevent nuisance from effluvia, Jones's "Fume Cremator" is now being adopted as an adjunct to consume the gases given off. It is constructed in the base of the chimney-stack, and the gases are exposed to a temperature varying from 1000° to 1500° Fahrenheit.

CHAPTER XI

PURIFICATION AND UTILISATION OF SEWAGE

It has already been shown, in the previous chapter, that of all methods of sewage-removal, the water-carriage system is the one which best meets the requirements of large towns. It is the speediest, cleanest, and, in the long run, the most economical method which can be employed on an extensive scale, and its general sanitary advantages are now placed beyond dispute. But no sooner had this difficult hygienic problem been solved by engineering skill than another of even greater difficulty arose. The eagerness of early sanitary reformers to get rid of human refuse at any cost blinded them to the fact that, by pouring sewage into the nearest watercourse, they were merely removing the evil from one place to take effect somewhere else. No consideration was paid to the probable results of the method on the future water-supply of increasing populations, nor to other serious consequences which speedily began to declare themselves. Rivers were in reality converted into sewers, and the communities down stream, while they loudly complained of the annoyance and danger to health, added to the nuisance by following the general example. After a time it was discovered that the mouths of navigable rivers were being silted up, that valuable stocks of fish were destroyed, that water-supplies were contaminated, and that riparian rights

were in every sense grossly violated. Such were some of the more important evils resulting from river-pollution, and eventually legal prohibitions were issued in many places to prevent their continuance. These prohibitions have multiplied, until the sanitary authorities throughout the country are at last compelled to purify the sewage of towns before it is discharged into any watercourse at a distance from the sea, or run the risk of incurring legal penalties; while the Rivers Pollution Act of 1876 absolutely prohibits any new drainage-works which may in future be carried out from discharging into any river or stream without previous purification.

Meanwhile there has been an increasing number of economists who have rightly maintained that sewage was not only wasted, but worse than wasted, when discharged into rivers, and that, on account of its manurial value, its proper destination was the soil. Hence has risen the larger question of the utilisation of sewage, the merits of which will be best understood by considering first the composition of town-sewage.

Section I.—Town-Sewage.

In addition to excretal matters, town-sewage contains the effete products of various trades and manufactures, animal and vegetable *débris*, mineral detritus from roads and streets, and the like, all of which are held in suspension or solution by an amount of water varying according to the water-supply in the first instance, and depending, in the second place, on the rainfall and amount of subsoil-water entering the sewers at different times of the year. This varying amount of water is one of the chief difficulties to be encountered in the utilisation of sewage, and, apart from other considerations, it has led engineers to recommend the introduction of the separate system,

when there is no difficulty of dealing with the rainfall. The sewage delivered from pipe-sewers, consisting almost exclusively of excretal matters, slops, and the water supply, can of course be readily estimated in all cases, and is much more easily dealt with. But with common drain-sewers, which receive in addition the rainfall and subsoil-water, not only is the extent of dilution much greater, but it is constantly varying in amount. With pipe-sewers, however, the amount of sewage equals the amount of water-supply, and in towns supplied on the constant system, this ought not to exceed 30 gallons per head daily, or about 50 tons per head per annum. In the face of such considerations as these, the sanitary and practical importance of Mr. F. O. Ward's famous alliter ative dogma of "the rainfall to the river, and the sewage to the soil," becomes at once apparent.

But, with either system of sewers, the value of the sewage may be said to depend entirely on the excretal matters, and the amount and relative value of these will be gathered from the following data:—

The subjoined table represents, as the result of numerous analyses, the average amount and composition of excretal matter discharged by a male adult daily:—

	Fresh Excrements.	Dry Substances.	Mineral Matter.	Carbon.	Nitrogen.	Phosphates.
	Oz.	Oz.	Oz.	Oz.	Oz.	Oz.
Fæces	4·17	1·041	0·116	0·443	0·053	0·068
Urine	46·01	1·735	0·527	0·539	0·478	0·189
Total	50·18	2·776	0·643	0·982	0·531	0·257

In a mixed population, the actual amounts per individual will obviously be considerably below this average, and, as stated in the previous chapter, they may be estimated at $2\frac{1}{2}$ oz. fæcal matter and 40 oz. urine daily,

—the fæces containing 23·4 per cent dry solids, and the urine 4·2 per cent. But the above table also shows that the manurial value of the urine voided in the twenty-four hours greatly exceeds that of the fæces passed in the same time. Indeed, the relative value, as determined by numerous analysts, is approximately as 6 to 1.

The actual value of both urine and fæces in sewage has been estimated at 6s. 8d. per individual per annum, supposing that 10 lbs. of ammonia is a fair estimate of the amount voided in that time. When the sewage averages 24 gallons daily per individual—that is, 40 tons per head per annum—its money value, according to this estimate, would be 2d. per ton, and the value per ton will decrease in proportion to the rate of dilution above this average. It may be added that this estimate corresponds very closely with the money value of average sewage given in the First Report of the Rivers Pollution Commissioners (1868); for it is there stated that "the value of the *dissolved* constituents in 100 tons of average sewage is about 15s., while the *suspended* matters only contain about 2s. worth of them." In other words, 100 tons are worth 17s., or about 2d. per ton. But no matter what may be considered the theoretical value of sewage in its crude state, it has long since become a question of least cost as regards its disposal.

The following table, from the Report of the Rivers' Pollution Commissioners, gives the average amount of solids in water-closeted and midden towns (see Appendix) :—

	Per 100,000 Parts.	
	In Solution.	In Suspension.
Water-closeted Towns . .	72	44·5
Midden Towns	82·5	39

SECTION II.—SCHEMES FOR THE PURIFICATION AND UTILISATION OF SEWAGE.

These have generally been classified under the separate headings of precipitation, filtration, and irrigation processes, and the more important of them which have been tried or are still in operation are as follows:—

1. *Precipitation Processes.*—In all of these processes the main object in view is the purification of sewage by the introduction of chemical agents. The dissolved matters are precipitated to a greater or less extent, and can therefore be separated along with the suspended matters, while the effluent water is supposed to be in a sufficiently pure state to allow of its being discharged into a stream or river without producing any serious degree of pollution. It is needless to say that many of these processes have proved to be signal failures, chemically as well as financially. Fictitious values were given to the resulting manure, and some of the schemes which otherwise might have proved fairly successful, were simply ruined by being made stock-exchange speculations. Indeed, it cannot be too widely known that, no matter what process may be adopted, Sanitary Authorities must be prepared to pay a subsidy for the chemical treatment of their sewage, because it is now clearly established that the manure, or whatever other products may be obtained, will in no case pay, or nearly pay, for the cost of purification. For it is found that whatever process is adopted, the ammonia is left untouched, and, along with a large percentage of the dissolved organic matter, it escapes with the effluent, so that the sludge becomes comparatively valueless as a manure.

To ensure the best results from precipitation, it is essential that the sewage should be delivered fresh, and that it should be well mixed with the chemicals used

before it discharges into the tanks. These tanks, as already pointed out, should be arranged in duplicate series varying in size and number according to the volume of sewage to be treated. They should be at least 4 feet in depth, and the effluent flowing out should pass over weirs not more than $\frac{1}{2}$ inch below the surface. The floor of each tank should slope to a well in one of the lower corners, from which the sludge can be pumped out when the tank is emptied for cleansing purposes. This emptying and cleansing of the tanks must be carried on at regular intervals, otherwise the sludge soon becomes putrid, and on rising to the surface gives off offensive gases. The sludge, which contains 90 to 95 per cent of water, may be conveyed along raised carriers on to land, as at Birmingham, and subsequently dug into the soil; or it may be treated in hydraulic filter-presses, which strain out the greater portion of the water and convert the sludge into solid cakes. The sludge of the London sewage, which results from the admixture of manganate of soda and sulphuric acid, is pumped into barges which carry it out to sea.

Amongst the numerous precipitating agents which have been tried from time to time, it may be said that lime, sulphate of alumina, and protosulphate of iron, used either singly or in combination, have yielded the best results. If either lime water or milk of lime is added to sewage the lime combines with the free carbonic acid, or it decomposes carbonates of the alkalis contained in the sewage to form an insoluble carbonate of lime, which slowly sinks to the bottom, carrying with it a considerable portion of organic matter, so that a more or less clean effluent is the result. Except when the sewage is acid, the proper amount of lime to be added, according to Dr. Stevenson, should not exceed the hardness of the water-supply. In other words, if a town supply shows 15 degrees

of hardness, then 15 grains of lime per gallon of sewage is the amount of lime required. Should lime water be used, 3 to 5 grains would be sufficient. If too much lime is added, the sludge and effluent become alkaline, and putrefactive change sets in more readily. The quantity of lime which is generally used is 1 ton to 1,000,000 gallons of sewage.

When sulphate of alumina is added to sewage the sulphuric acid combines with lime and other bases in the sewage, hydrated alumina oxide is formed, and the resulting flocculent precipitant carries down most of the suspended organic matters with it as it slowly subsides. The effluent, however, is slightly acid, and better results are obtained by a mixture of lime and sulphate of alumina in the proportion of 5 grains of lime and 5 grains of sulphate of alumina per gallon of sewage. Mixed in these proportions, a purer effluent is produced than when either substance is used singly, and with a sewage of average composition, the effluent, if not quite neutral, is nearly so.

If a salt of iron is added, such as protosulphate of iron, the sulphuric acid combines with the lime salts, protoxide of iron is formed which acts as a powerful antiseptic, and the precipitant carries down with it large quantities of organic matter, some of which it may oxidise. When used with lime, it should be added in the proportion of from 2 to 5 grains per gallon of sewage. If used alone, the effluent is somewhat acid, but in any case its use is attended with this disadvantage—that when the effluent is discharged into a stream the banks become blackened by the sulphide of iron which is subsequently formed, and are rendered very unsightly, even when they do not become offensively foul.

Several of the following processes have been tried and failed, while others are still in use, and have been attended with more or less success :—

(1.) *Lime Process:*—This process, which has been tried at Blackburn, Leicester, Tottenham, and other places, is only useful in clarifying sewage. It is still employed at Birmingham, Bradford, and other towns. The lime is mixed with the sewage in the outfall sewer some short distance from the tanks. At Birmingham the sludge is dug into the ground, and the effluent is utilised and purified over a large sewage farm. In *Scott's process,* which was tried at Ealing and West Ham, clay is added to the lime and thoroughly mixed with the sewage in the outfall sewer. The sludge was dried and burnt, and subsequently converted into cement or bricks.

(2.) *Alumina Processes.*—*Bird's process,* which was tried at Cheltenham but abandoned, consisted in the addition of crude sulphate of alumina, and subsequent filtration through coke. The sulphate of alumina was obtained by treating pulverised clay with strong sulphuric acid. In this, and *Stotherd's process,* which somewhat resembles it, the effluent was not found to be sufficiently purified for admission into any river.

In *Anderson's process,* which is still carried on at Coventry, the sewage is mixed with a saturated solution of sulphate of alumina heated to the boiling point, and afterwards with milk of lime. The sludge is treated in Johnson's filter-presses, and the effluent is subsequently run on to land, but the area is too limited to secure efficient filtration, and there is therefore serious pollution of the adjoining stream.

(3.) *Salts of Iron.*—In the process carried out by the Sewage Purification Company, powdered magnetic ore is treated with sulphuric acid, and sulphate of iron is formed. This is added to the sewage in due proportion, but the resulting effluent is acid.

(4.) In what is called the *A. B. C. process,* which is now carried on at Aylesbury, a mixture of alum, clay,

magnesic sulphate, charcoal, and blood is added to the sewage. The blood probably has little or no effect, but the clay carries down with it the precipitating matters, and the resulting effluent is highly clarified.

(5.) In *Hanson's Process,* which is carried on at Leyton and Tottenham with fair success, black-ash waste is used in conjunction with lime. The waste is prepared from the refuse of alkali works which has long been exposed to the air, and contains sulphites and hyposulphites of lime, which act as powerful deoxydising agents.

(6.) *The Electrolysis Process.*—This process, which was invented by Mr. Webster, F.C.S., has been tried experimentally at Crossness. The sewage is electrolysed by passing through long troughs fitted with large iron plates, and the electricity is supplied by a powerful dynamo. The chlorides in the water are split up at the positive pole, and the chlorine and oxygen unite to form hydrochlorous acid. This partly attacks the organic matter and also the iron plates, forming ferrous hypochlorite, which in its turn is acted on by the bases of ammonia, sodium, potassium, etc., set free at the negative pole, and converted into ferrous hydrated oxide, which becomes the precipitating agent. The process would appear to be a costly one.

(7.) At Acton a process is carried on which is said to yield very good results, in which the precipitant is a material called *ferrozone.* This consists of a mixture of protosulphate of iron, alum and magnesia, and magnetic oxide of iron. After treatment with the ferrozone, the effluent is filtered through a bed of *polarite.*

(8.) *The Amines Process.*—This process, which recently attracted a considerable amount of attention, is carried on at Wimbledon. It consists in adding lime and a small amount of herring brine to the sewage. The brine contains ammonia compounds known as *amines,* and

when these bases are added to milk of lime the gaseous re-agent *aminol* is produced, which acts as an antiseptic and germicide. The precipitation is rapid, and the effluent does not decompose, but on a large scale the process must be a costly one.

Such are some of the more prominent chemical processes which have been tried or are still in operation, but with respect to all of them it may be said that they fail in producing a uniformly good effluent unless it is supplemented with land filtration or irrigation. Many of the effluents can, however, be discharged into a river if the volume of river water is large compared with the volume of effluents; or if the stream or river is already highly polluted, a fairly good effluent will not increase the pollution, but may have an opposite effect.

In manufacturing districts serious pollution is often caused by the discharge of waste liquid refuse into streams and rivers. A more rigid enforcement of the Rivers Pollution Act would greatly mitigate the evil without in many cases entailing any heavy outlay. Indeed, in some cases the purifying operations have resulted in a profit. Suitable chemical and filtration processes would, in the great majority of instances, satisfy all the requirements of the Act.

2. *Filtration Processes.*

(1.) *Simple filtration.*—In this process, whether the filtration be downward or upward, the sewage is merely strained or screened through gravel and rough sand, so that though almost all the suspended matters are removed, the effluent remains unpurified.

(2.) *Carbon,* as in Weare's process, has been used to purify sewage, but the process does not appear to have been very successful. Very possibly, if it could be obtained at a cheap rate, and the filtration were made

intermittent, it would be found to answer with small quantities of sewage where land cannot be procured.

(3.) *Ferruginous Filtering Media.*—In addition to *polarite,* which, as already mentioned, is used for filtering the effluent in the Acton process, magnetic carbide of iron may be mentioned as a powerful oxidising agent. But in order to obtain the best results, the sewage should be first precipitated, and the effluent afterwards passed through filters of magnetic carbide covered with fine sand. The filtration should be slow and intermittent to permit of aeration of the filters, and the sand and carbide should be laid in beds of 12 and 18 inches thickness respectively. The magnetic carbide converts the ammonia and organic matters contained in the effluent into nitrates and nitrites, and when once in position does not require renewal. A filtering area of half-an-acre would be sufficient to purify half-a-million to a million gallons of effluent in the twenty-four hours. This process commends itself when it is not possible to obtain land for the purpose.

(4.) *Intermittent Downward Filtration.*—This process of filtration is the only one which yields satisfactory results. The soil should be of a porous and loamy character, and should be drained to an average depth of 6 feet, with varying distances of from 10 to 20 feet between the drains. Sandy soils are not so suitable, and clay and retentive soils should be broken up and mixed with ashes. The surface of the land must be levelled, and it is generally the practice to lay out the filter beds in ridges and furrows,—the sewage flowing along the furrows, whilst vegetables are grown on the ridges.

The purification of the sewage is partly effected by simple filtration, but in a far greater degree it is due to the oxidising properties of the soil, which convert the ammonia and inorganic matters into nitrates and nitrites.

As this oxidation depends in great measure upon the efficient aeration of the soil, it is necessary that the sewage should be applied to different portions of the filtering area alternately. Thus, if the area is divided into four equal parts, each section should receive the whole of the sewage for six hours in succession, and leave an interval of eighteen hours for rest and aeration. The aeration of the soil, too, is of special importance, because the bacterial organisms, which are the chief agents in nitrification require air and oxygen for their growth and activity. These nitrifying organisms, which have been described by Schlœsing, Warrington, and others, exist in all soils, and are found to a depth extending to 3 or 6 feet from the surface. They are especially abundant in rich loamy soils, and they act as powerful oxidising agents by feeding on the ammonia and organic matters contained in the sewage. In order that the nitrous and nitric acids produced by their action should combine with bases, the soil or sewage should be rich in salts of lime, otherwise the nitrifying process is greatly impeded.

The requisite extent of filtering area for intermittent downward filtration varies according to the nature of the soil, but if the sewage is first clarified, one acre of loamy porous land would be sufficient to purify the sewage of 3000 inhabitants. If the sewage is applied in its crude state, the estimate is one acre to every 1000 of the population, but this too will depend largely on the character of the soil. When crude sewage is applied to small areas of land, the surface and pores of the soil are apt to become clogged with slimy matters, and the surface should therefore be frequently broken up. In stiff clayey soils, again, large cracks are apt to form during warm weather, down which the sewage may run directly into the subsoil drains, and when the filtering area is neglected moles and rats speedily make other openings for the

passage of the unfiltered sewage. Under favourable circumstances, however, and with proper attention, the effluent water issuing from the deep drains will be found to be almost entirely free from organic matters. The amount of chlorine in the sewage will not be found to be materially reduced, but the whole of the nitrogen will only exist in the harmless form of nitrates and nitrites. Land filters planted with osiers are sometimes employed for the purification of village sewage, and these osier beds are often a useful adjunct to filtration areas for the occasional treatment of storm water.

The process of intermittent downward filtration is successfully carried out at Abingdon, Malvern, Barnsley, Hitchin, Kendal, Merthyr-Tydfil, and Forfar in Scotland.

3. *Irrigation.*—It is now generally conceded that this is the only process which fully meets all the requirements attaching to the disposal of sewage; in other words, it is the only one which, while it purifies the sewage efficiently, realises the highest profits, and may be carried on without creating any nuisance or detriment to the health of the neighbouring inhabitants. But in order that the process may be carried out satisfactorily, it is necessary—

(1.) That the acreage be sufficient. This will depend in great measure on the looseness or porosity of the soil; —hence to lay down as a rule that one acre should be allowed for every 100 inhabitants, which is the estimate usually given by engineers, is manifestly illogical.

(2.) The land to be irrigated must be drained, and stiff clayey soils broken up and mixed with ashes, sand, or lime.

(3.) The surface must be irrigated on the intermittent system, to ensure sufficient æration of the soil.

(4.) The ground should be laid out in broad ridges and furrows, the sewage being conveyed along the tops of

the ridges in open carriers, and made to flow gently down the slopes by inserting temporary sluices in regular succession and at regular intervals. At Breton's Farm, near Romford, the breadth of the ridge is 30 feet, giving a slope of 15 feet on either side of the carriers. At Lord Warwick's Farm near Leamington, the ridge varies from 50 feet wide and under, according to circumstances. If the surface of the ground slopes, ridges may be dispensed with, and the grips or carriers dug at varying distances as required.

(5.) There must be a rotation of crops, such as Italian rye-grass, peas, maize, different roots, cabbages, etc., and where land is plentiful, it always pays to let portions of it rest for a time for the growth of cereal crops.

(6.) The sewage should be delivered in a fresh state, and freed from the coarser portion of its suspended matters. This may be effected either by precipitation, filtration, or screening. At Lord Warwick's farm the borough of Warwick farm, and the Rugby farm, the sewage is simply screened and delivered fresh on to the land.

A large well-drained filter bed is of great service to a sewage farm, to receive the whole or part of the sewage at times when the farm is unable to cope with it. Such a filter bed should, however, only be used on the intermittent system.

Such, briefly, are the principal details connected with sewage-farming, and it is the neglect of one or more of them which has brought so much opprobrium on the system. If the irrigated soil becomes water-logged and swampy, the fault lies with the engineering and management, not with the system. Or, again, if the farm becomes a nuisance, it is because the sewage is not properly distributed, or the carriers kept free from deposit.

The comparative results of the different processes of

purification are stated by the Rivers Pollution Commissioners as follows:—

Average Results.

	Percentage of Dissolved Organic Pollution removed.		Percentage of suspended Organic Impurity removed.
	Organic Carbon.	Organic Nitrogen.	
Chemical processes	28·4	36·6	89·8
Upward filtration	26·3	43·7	100·
Downward filtration	72·8	87·6	100·
Irrigation	68·6	81·7	97·7

This table shows that, in order to obtain the best purifying results, irrigation should always be combined with intermittent downward filtration. With regard to towns where a sufficiency of land cannot be procured for irrigating purposes, the process of intermittent downward filtration should be adopted, and this may or may not be supplemented by precipitation, according to circumstances. Owing to the high rent of land few sewage farms can be worked at a profit, although Lord Warwick pays a rent of over £200 a year for the sewage of Leamington.

Where no land can be procured, as in the case of numbers of large inland towns, recourse must be had to purification by some chemical process; but in many instances the difficulties are so enormous that the pollution of neighbouring streams cannot be prevented unless at a cost which would irretrievably ruin commercial enterprise. Even were all trade-refuse and sewage excluded from streams, the mere surface-washings of large towns are sufficient of themselves to convert many of them

into foul rivers, which no legal enforcement of riparian rights nor any number of Rivers Pollution Bills can ever render pure. Indeed, at Birmingham, Leeds, and other inland towns, the effluent is much purer than the filthy streams into which it discharges. Sanitary reformers are too apt to forget that, though streams and rivers may, and often do, prove valuable sources of water-supply, they are nevertheless the natural drainage outfalls of the country: and while many of them may be preserved from injurious pollution, there are numbers of others doomed to such an amount of pollution that, no matter what preventive means may be adopted, fish cannot live in them, and their turbid waters, however carefully purified, can never be safe to drink. It is evident, therefore, that with regard to river pollution the special circumstances of every large town involved in sewage difficulties must be taken into account, and that no hard-and-fast rule can be enforced by Act of Parliament which shall be applicable to all alike.

The Rivers Pollution Commissioners recommended that no effluent should be allowed to discharge into a stream which exceeded the following standard :—

		100,000 Parts
Suspended Matter	Dry organic	1
	,, mineral	3
Dissolved Matter	Organic carbon	2
	,, nitrogen	0.3
Metals (except calcium, magnesium, potassium, or sodium)		2
Arsenic		0·05
Chlorine (free after addition of sulphuric acid)		1
Sulphur (as sulphides)		1
Acidity (hydrochloric acid)		2
Alkalinity (caustic soda)		1
Oily matter (petroleum or hydrocarbon oil) or any film of oil on the surface.		0·05

Colour. Any distinct colour in depth one inch when examined by daylight in a white vessel.

It may be stated here that the Thames Conservancy Commissioners do not insist upon so high a standard.

Section III.—Treatment of Village Slops

The satisfactory treatment of village slops is often a very difficult question, partly because, in the case of old villages, the drains are so radically defective that pollution of air and water are in many instances alike common. The shallow road-drains, which were intended, when first laid down, to carry off the surface-water, and which, for the most part, are generally constructed of common drain-pipes, or loosely laid bricks or stones, have been converted into common sewers by conveying into them the badly laid and open-jointed drains leading from almost every house or group of houses in the village. If there be a water-course near the village, the drainage discharges into the stream by one or several outlets, as the case may be. Should it happen, however, that the village is some distance from a stream, then it is found that the slops discharge into open ditches by the roadside, or into field-ditches in the immediate neighbourhood of houses, and thereby often give rise to filthy nuisances in every direction. This description, it is true, only applies to the worst drained villages; but in almost all of them some of these defects are to be met with. Shallow, unevenly laid, and leaky drains are especially common; and as these are not only liable to pollute any wells which may be near them, but, in consequence of the want of proper means of flushing, permit of filth-accumulations which give off noxious effluvia, they are a source of constant danger.

And this description, it should be remembered, applies to villages in which water-closets do not exist at all, or are very rare, so that the whole of the nuisance may be

said to depend upon the disposal of the slop-water. The question, therefore, at once arises whether in any given case a new system will be required, or the existing system improved to remove nuisance, or whether the slops can be satisfactorily disposed of in some other way. In compact villages, or villages of any size, a system of drainage is absolutely necessary, because the multiplication of dumb-wells or cesspools in villages, as in towns, is always attended with danger, and ought to be avoided as much as possible.

If the drainage of a village is found to be fairly satisfactory, and the drains discharge into a large stream which is not used for drinking purposes below the village, it may not be necessary to interfere, provided there is no nuisance at the outfall. If, again, the village drains into one or more field ditches, which can be kept free from nuisance by periodical cleansing on the part of the Sanitary Authority, such a mode of disposal may be deemed sufficient. But in all cases in which there is nuisance at the outfall or risk of water-pollution used for drinking purposes, the sewage, if it be at all possible, should be purified by irrigation, or it should be filtered through a filtering area of sufficient size and on the intermittent downward filtration system. In some cases the outfall drain may be carried alongside a field ditch of lower depth, and the soil between will act as a ready filter. If land has to be purchased, an acre of ground properly drained and laid out would be quite sufficient to purify the slops and refuse-water of a village containing 1000 to 1500 inhabitants, provided the sewage is applied on the intermittent system and the subsoil is porous. Of course if simple irrigation should be carried out, some three or four acres would be required, but the ground should be drained and properly levelled, and to secure intermittency and sufficiency of flow an automatic sewage-

meter tank should be provided, or two sets of tanks which could be discharged alternately as required. Very often the quantity of sewage is so small that unless a tank or tanks are provided the sewage trickles along the surface grips and finally disappears, without contributing any of its fertilising properties to the surface of the ground.

For isolated houses or groups of houses, a very satisfactory way of dealing with the slops is by sub-irrigation. In sub-irrigation the drains consist of common agricultural pipes laid at a depth of about 12 inches below the surface upon a bed of larger pipes divided longitudinally in half, so that the slops soak through between the open joints into the subsoil, part of them filtering into the ground, and part of them being absorbed by the vegetation on the surface. The system may be used in gardens provided the surface of the ground slopes away from the houses, and is especially applicable to land which is reserved for pasture land. The drains should be taken up and relaid at least once a year, and it is always advisable to have the subsoil deep-drained. Care, however, must be taken to avoid pollution of wells by laying a longer or shorter portion of water-tight drain according to circumstances. In some cases a cesspool or dumb-well will answer very well to receive the sewage, provided it is far enough removed to obviate any risk of well pollution, but where the slope of the ground is sufficient, a better plan is to connect the drains with a Field's self-acting flush-tank (see Fig. 12, page 302).

Section IV.—Sanitary Aspects of the Water-Carriage System of Excretal Removal and Disposal.

So much has been already said with regard to the evils resulting from collections of excretal matters in towns that at first sight the superiority of any system

which prevents these accumulations would appear to be placed beyond dispute. Unfortunately, however, the sewer system is by no means free from dangers, and these have been attended with such disastrous consequences that at first many were led to condemn it altogether. But it has long since been clearly proved that the few important outbreaks of enteric fever which have been attributed to the water-carriage system, were due to faults in the system and not to the system itself. Indeed the very fact that this disease has exhibited a remarkable decrease of late years, and especially in water-closeted towns, affords the strongest argument that the water-carriage system, as it is the cleanest, is also the safest, provided that house-drainage as well as public drainage are carried out on sound sanitary principles and receive proper attention as regards flushing.

With regard to sewage-disposal it has already been shown in the previous chapter that irrigation is the only method which sufficiently purifies the sewage, and at the same time secures the best return of outlay in agricultural results. It now remains to be seen whether the carrying out of the system is attended with danger to public health. And here it may be premised that the same difficulty is encountered in sifting evidence as throughout the whole sewage-question,—the difficulty, namely, of dealing with sweeping generalisations which have been based on isolated or exceptional cases. For while, on the one hand, it appears that the late Dr. Letheby and others have condemned all sewage farms as pestilential swamps, Dr. Carpenter of Croydon and other strenuous advocates of the system, so far from pronouncing them as in any way dangerous to health, maintain that the general health of the neighbouring inhabitants is actually improved by them. But this is pushing the argument too far on both sides. No doubt some sewage farms answer to Dr. Letheby's

description, especially such farms as have been laid out, without any due regard to drainage, in low-lying districts, and those that have been planned on the "catch-water" system. It is evident that this latter system necessitates a swampy condition of both soil and subsoil, unless the ground is porous and well drained, inasmuch as the sewage passes over successive areas of land, overflowing from each into a "catch-water" ditch, which conveys it to the next. Again, when the sewage is not delivered in a fresh state, and at least properly strained, if not disinfected by some precipitation process, offensive emanations are undoubtedly given off, especially when the carriers are not kept clean. But though all this is perfectly true, it is no argument against the system when properly carried out, unless direct evidence can be brought forward to show that, even when the engineering and management are alike satisfactory, there is not only possible but actual risk to health. Such evidence, however, does not appear to be forthcoming; and even with regard to farms which have neither been planned nor are conducted according to the most approved principles, the evidence as regards the production of disease is of a negative character. In my own district, containing at least ten sewage farms, and some of them of considerable size, no cases of illness which could be traced to this source have ever come under my notice. So far, therefore, the production of disease arising from fæcal pollution of air or water by the system, when properly managed, is not substantiated. But it was feared at one time that entozootic diseases would be greatly propagated, no matter how efficiently the system might be carried out, and the late Dr. Cobbold's high authority gave currency to the belief. Dr. Cobbold, however, with rare scientific candour, and after careful investigation, afterwards stated that the fears which he originally entertained had not been realised. Animals fed on sewage

produce have not been found to be parasitically diseased, nor has any case of parasitism been detected in man which could be traced to the effects of sewage irrigation.

Alarmists, too, have not been wanting, who strenuously maintain that the milk of cows fed on sewaged grass is poor in quality, rapidly decomposes, and is unfit to be used. But so far is this from being the case, that there is an overwhelming amount of evidence to the contrary; and the butter as well as milk yielded by cows fed on sewage grass has invariably stood the test of numerous and careful analyses with the most satisfactory results. It need hardly be said that on a well-conducted sewage farm, no sewage is applied for several days before the grass is mown, so that it is always perfectly clean.

CHAPTER XII

SOILS AND LOCALITIES—THEIR INFLUENCE ON PUBLIC HEALTH

WHAT is called the Geographical Distribution of Disease, except where studied in respect to vast tracts of country and different climates, depends upon so many complex conditions, that it becomes very difficult to determine what may be the precise influence on health exerted by the purely physical features of soil or locality. We know, for example, that the class of diseases which characterise the tropical zone are the worst kind of malarial fevers, associated more especially with dysentery, diarrhœa, cholera, specific yellow fever, and hepatic affections, and that these fevers prevail with the greatest intensity in flat low-lying tracts of country, in the vicinity of marshes, the borders of lakes, the shores of the sea, and the banks of rivers. Indeed the geographical data collected by medical writers from the days of Hippocrates downwards go to prove that every country is unhealthy in proportion to the extent of undrained alluvial or marshy soil which it contains, and that the excess of disease engendered is mostly of the remittent and intermittent febrile type. In the time of Sydenham, London was infested with epidemic intermittent fever and dysentery; but for years back, owing to the construction of sewers and a general system of deep drainage, cases of ague contracted in London are hardly known. Other towns, both in this country and France, such as

Portsmouth, Bordeaux, and Rochefort, which were once the seat of malarial diseases, have in like manner been rendered comparatively healthy. Even in the fen districts of Suffolk and Norfolk ague, which was once so common, is now dying out, owing to the drainage improvements which have been instituted.

But when we come to study the distribution of disease in a country so limited in extent as Great Britain, and with climatic conditions so fairly uniform throughout, the process of eliminating other than purely local causes becomes exceedingly difficult. For example, we know that phthisis is much more prevalent in certain localities than in others; but in many of these districts it is found that heredity, consanguineous marriages, poor feeding, overcrowding, or industrial occupations, play a far more important part in the production of the disease than topographical conditions. Indeed, it may be said generally that the purely artificial conditions in and around dwellings are of far greater moment from a public health point of view, in this country at all events, than geological formation or nature of subsoil. Nevertheless, geological conditions, in so far as they influence surface conformation, and the movement of water and air in the soil of different localities, are very important factors in the maintenance or impairment of health, and merit special attention in sanitary investigations.

SECTION I.—TOPOGRAPHICAL CONDITIONS.

These refer to the configuration and elevation of the surface, the exposure to certain prevailing winds or otherwise, and the relations to watersheds or river-systems. The expressions high and exposed, flat and low-lying, sheltered, sloping, undulating, and the like, have a certain though varying significance, in differen-

tiating the various factors affecting the salubrity of any given locality. In hilly districts, the most unhealthy localities are enclosed valleys and ravines where the air cannot circulate freely and must stagnate, while, as regards a comparatively flat district, the insalubrious spots are depressions below the level in which the subsoil water crops up to the surface. Vegetation has also an important bearing on the health of a locality. Herbage on sound soils is always healthy, but isolated country houses and small villages embowered among trees and low-lying, become unhealthy when the trees are so plentiful that they interfere with the free movement of air, and this unhealthiness is increased when the autumn leaves are falling. The banks of sluggish rivers which are flooded in times of heavy rainfall are always more or less unhealthy, and so too is the neighbourhood of flat estuaries, where the mists creep up in the evening and hang in the early morning.

Section II.—Geological Conditions.

These refer to the nature of the soil and the geological formation. Made-up soils become purified after a time by oxidation and the process of nitrification referred to in the previous chapter, but as a condition of purification the subsoil water must have a free outlet. No building should be permitted on sites of this description without making trial-holes and ascertaining whether all the organic matters have become decomposed; and even then the surface should be asphalted or concreted over, and free ventilation under the floors secured. Sandy and gravelly soils are always healthy except when they lie much below the general surface, and thus become water-logged. Clay and dense marls, on the other hand, are not so healthy unless the surface is undulating and

there is a good fall in streams and brooks for the removal of the surface and subsoil water. Low-lying clayey soils are cold and damp, and favour the development of phthisis, rheumatism, and catarrhs.

As regards geological strata, it may be said generally that the granitic, metamorphic, and trap rocks are usually healthy. The surface conformation is hilly or undulating, the air is comparatively dry, and the rainfall rapidly runs off. So, too, with the clay slate formation; but water is often very scarce. In districts where the limestone and magnesian limestone formations prevail, the surface is generally undulating and healthy, but water is always hard, and often difficult to find. Of the different kinds of limestone, oolite is considered to be healthier than magnesian limestone; indeed goitre and calculus are more common in districts where this latter formation abounds than elsewhere. The chalk formation, when permeable, is very healthy, but where it overlies beds of clay it often becomes marshy and malarious, as in large tracts of America. The permeable sandstones and hard millstone grits are also healthy, and so, too, are gravels from which the subsoil water can drain freely away. But the principal factors which influence the salubrity of the subsoil of a locality are its power to absorb and retain heat, the character and movements of the ground air, the process of nitrification, and the nature, movements, and level of the subsoil water.

1. As regards power of absorbing and retaining *heat*, no extended series of observations, except those of Schübler, have yet been made; but according to him sand heads the list, then (in order), light clay, gypsum, heavy clay, clayey earth, pure clay, fine chalk, and, lastly, humus. No doubt the temperature of the soil exerts a very considerable influence on the nitrification and oxidation of any organic matter which it contains,

and therefore assists in determining the character of the ground air.

2. *Nitrification.*—As already pointed out in the previous chapter, the process of purification in all soils depends upon the presence of minute organisms, which convert the nitrogen of organic bodies into ammonia, and subsequently into nitrites and nitrates. These micro-organisms, as described by Shlœsing, Muntz, Warrington, and others, consist of *micrococci* and *bacilli,* which vary in numbers according to the amount of organic matter in the soil and the depth from the surface. They are rarely found below 12 or 15 feet, and are most numerous near the surface. It appears to be of the first necessity that the soil should be alkaline, as carbonates of potash and lime are most favourable to their activity, while sand without lime is found to impede their action. Along with the oxidation of nitrogenous matter produced by these fermentative organisms there also proceeds the oxidation of organic carbon; the one process being, in fact, the complement of the other. The soil must be moist, and it must also be well ærated, while the most favourable temperature for the highest activity of the process is 98° Fahr.

Pathogenic organisms are not propagated near the surface of the soil, because they are, as a rule, destroyed by these saprophytes. In the deeper layers, however, they may be preserved for a long time in a dormant condition. Indeed, Pasteur and others have found the *bacillus anthracis* in soil thirteen years after animals which had died of *charbon* had been buried.

3. *Ground Air.*—The nature of the ground air has been examined by many observers, and notably by Pettenkofer, Fleck, Fodor, and Nicholls of America. Its composition and amount are very variable, but its chief ingredient is carbonic acid gas, due no doubt to the

oxidation of the organic matter contained in the soil. Occasionally it contains carburetted hydrogen, ammonia, and nitric acid, and in soils more or less damp, and where the water is hard, owing to an excess of sulphates, a small amount of hydrogen sulphide is usually found. According to Boussingault's experiments the amount of carbonic acid varies from 2·4 per 1000 volumes to 9·74 in soils which have recently been manured, while Pettenkofer and Fleck have found it to rise as high as 80 per 1000 volumes in gravelly soils at depths of from 5 to 13 feet. Indeed, Pettenkofer has proposed that the amount of carbonic acid gas should be taken as the index of the other impurities, but this is manifestly open to objection, because the more porous the soil, the greater the amount of atmospheric air present. In order to estimate the porosity of soils, or the total amount of ground air, the following is the plan adopted by Pettenkofer. A sample of the loose soil is rubbed down to a powder, but without crushing it, and dried at a temperature of 100° Cent. (212° Fahr.) A portion of it is introduced into a burette, which is gently tapped to force the air out of the interstices as far as possible. This burette is connected with another by means of an india-rubber tube provided with a clamp, and this latter is filled with distilled water. The two are then fixed side by side on the same level, the pressure of the clamp is removed, when the water in the second burette flows into the first and gradually rises through the soil, until it appears as a thin film covering the top. The quantity of water which has thus passed from the second burette is then read off, and will represent the amount of air contained in the sample of soil, while the percentage of air in the soil will be obtained by the following formula: $\frac{a \times 100}{b}$, where a represents the amount of water used and b the quantity of dry soil.

It need hardly be said that not only does the quality of the air vary in different soils according to their nature, but it is constantly varying, owing to its continual movement, and especially where soils are dry and porous. These movements are largely influenced by temperature, barometric pressure, force and direction of winds, rainfall, and level of subsoil water. But there is another condition which, though artificial, exercises even a more important influence, so far as health is concerned, than perhaps any of these. For example, during cold weather a house which is well warmed, and has underground cellars or kitchens with no ventilated or impervious covering over the subsoil, is continually drawing air from the soil, and often from considerable distances. Thus the foul air from a cesspool, according to Dr. Fyffe, was sucked into a house a distance of 27 feet, and coal-gas from leaky pipes has been found to travel long distances. Dr. Reid, medical officer of health for Staffordshire, has recently recorded an instance of poisoning by carbonic oxide owing to air from a disused mine having found its way into the basement of a house in the proximity of the mine.

4. *Water in Soils.*—The water in soils is generally considered under two aspects, viz. the amount of water mixed with air to be found in any given soil, known as *moisture,* and that subterraneous lake or sheet of water which exists in all soils at varying depths, and known as *ground water.* The amount of moisture will depend on the nature of the subsoil, the amount of rainfall, the configuration of the ground, and the quantity of water derivable from the ground water itself. Some soils take up large quantities of water. A loose sand, for example, may retain as much as 2 gallons per cubic foot, and ordinary sandstone may hold 1 gallon. Clay takes up 20 per cent, chalk 13 to 17 per cent, and humus 40 to 60 per cent.

The amount of moisture in soil is determined by drying a weighed quantity at 220° Fahr., and weighing afterwards. If the dried air is placed over water in a bell jar, and again weighed, an estimate can be formed concerning its hygometric properties.

The ground water is in constant movement, and generally in the direction of the sea, or the nearest water-course. The level from the surface of the ground varies from 2 or 3 feet to several hundreds, and depends upon the porosity or compactness of the soil, the amount of rainfall, the configuration of the ground, and the dip and distance of impermeable strata. The variation in the level of the ground water, which can easily be measured in wells, is considered by Pettenkofer, Fodor of Buda Pesth, and others, to be a most important factor in the etiology of diseases, such as cholera and enteric fever.

Section III.—The Relations Between Soils and Localities and Disease.

As a general rule, it may be said that a persistently low ground-water level, say 15 to 20 feet, is healthy; that a persistently high level, say 5 to 3 feet, is unhealthy; and that a level which fluctuates suddenly and considerably is more unhealthy still, by reason of the fact that fluctuations in the ground level not only favour pollution of well water, but by forcing impure ground air into houses they must exercise a most important influence on health.

1. *Enteric Fever and Cholera.*—According to Pettenkofer, enteric fever is much more likely to become prevalent when the ground-water level is at its lowest, and no doubt this view has been corroborated to a very large extent by observations which have been made not only in Munich, but in other parts of Germany, such as Berlin

and Leipzig. This theory is based upon the assumption that in addition to impurity of soil from animal impregnation, which is acted on by temperature, moisture, and air, there must also be the entrance of a specific germ; and he also applies his theory to the causation of cholera. But in this country Pettenkofer's views have not been confirmed, and though outbreaks of enteric fever have been found to be associated with rapid rising or falling of the subsoil water, they have been originated by the polluted water in the wells, into which the ground impurities have been washed. It is quite probable, too, that there are other causes in operation which must materially effect the validity of any theory of the kind. For example, it is well known that the level of the ground water is lowest in the warm and dry seasons of the late summer and autumn, and these are the seasons when sewer and drain emanations become most prevalent and offensive. Then, too, there is hardly any fact which is more gratifying so far as sanitation is concerned than the steady decline of the prevalence of enteric fever in towns provided with a wholesome water supply, and with a drainage system properly constructed and ventilated, and kept regularly flushed. Indeed in many towns cases of enteric fever are now of the rarest occurrence, so much so that the disease may be said to be banished altogether; and yet in these towns there must be rising and falling of the ground water, though of course deep drainage must permanently lower its level. So far as the ground water is concerned, the fever-rate has diminished, because wells are no longer used. And here it may be pointed out that there are carefully investigated instances recorded, such as the oft quoted outbreak of enteric fever at Zurich, which are altogether subversive of Pettenkofer's theory, the disease rising and falling with the level of the ground water. But even in cases such

as this, it is highly probable that the real cause is the pollution of the well water; surface impurities and impurities in the subsoil being washed into the wells as the level of the ground water rises. Pettenkofer further maintains that the virulence of the specific contagia of enteric fever and cholera is specially intensified by warmth and dampness of subsoil, and this latter factor operates all the more powerfully when the ground water subsides rapidly after a sudden rise.

2. *Diarrhœa and Dysentery.*—There can be no doubt that both these diseases are largely influenced by conditions of subsoil. It has been pointed out in a previous chapter, for example, that polluted well water, alike in towns and country districts, is a fertile source of diarrhœa, while temperature of the subsoil, as Dr. Ballard has shown in his exhaustive inquiry into diarrhœal mortality, is an index of the dangers attaching to a filth-sodden subsoil. As the temperature rises, the sick and death-rate from infantile diarrhœa increases. In warm climates, the prevalence of dysentery is largely due to subsoil conditions. (See Chapter XV.)

3. *Malaria.*—It has frequently been matter for debate whether malarial fever is due to inhaling the air of marshes or drinking the water; but there is now a vast amount of evidence which proves conclusively that the air alone is frequently the medium through which the disease is conveyed, and the morbific agent is believed by many to be a specific germ known as the *Bacillus malariæ.* But whether the origin of the disease be microbial or not, the factors which are essential to its development are heat of soil, moisture, air, and a certain amount of impurity which in all probability is of vegetable origin. In so-called malarious countries, outbreaks of the disease may be connected either with the rise or fall of the ground-water level. Obstructions to outflow of the ground water,

as, for instance, during the construction of the Ganges and Jumna canals, have often been followed by wide-spread malarial epidemics; while epidemics quite as severe have been known to follow heavy rainfalls, succeeded by a rapid rise in the ground-water level, as at Kurrachee in Scinde, in 1869. Further, it has been noted that disturbances of the subsoil during the excavation of canals, the construction of dykes, and the reclamation of marshy land, by exposing the earth impregnated with organic matter to the energetic action of the sun, has often been known to be followed by increased prevalence of malarious disease. On the other hand, deep drainage, as has already been pointed out, removes the danger.

4. *Phthisis.*—Amongst the numerous valuable reports which Dr. Buchanan, in his capacity of Health Inspector, submitted to the Privy Council, there was perhaps none which excited greater interest at the time than his report "On the Distribution of Phthisis as affected by Dampness of Soil." In a previous investigation regarding the effects of improvements in drainage and water-supply, Dr. Buchanan had ascertained that in certain towns which had been improved in this respect, the mortality from phthisis had greatly diminished; and not only so, but the rate of diminution was found to correspond with the extent of the drying of the subsoil. This result, which was so far unexpected, led to the important inquiry above mentioned, and the principal facts connected with both may be briefly summarised as follows:—

In the first inquiry, it was found that wherever the drying of the subsoil had been effected, either by the construction of drain-sewers, or by special drains and deep storm-culverts, when the pipe-system was carried out, the mortality from phthisis had decreased from about 50 per cent downwards. In Salisbury, for example, the

death-rates from phthisis had fallen 49 per cent; in Ely, 47; in Rugby, 43; in Banbury, 41; and in thirteen other towns the rate of diminution, though not so marked, was nevertheless noteworthy. On the other hand, it also became apparent that in certain towns, such as Alnwick, Stafford, Morpeth, and Ashley, where no drying of the subsoil had been effected, there was no reduction in the phthisis death-rate, even although the greatest possible progress had been achieved in the removal of filth. This was owing to the fact that in these towns impervious pipe-sewers had been laid down, without making any provision for deep subsoil-draining, the storm water being carried off in superficial culverts. In some towns, again, such as Penzance, where the subsoil was already dry, the phthisis death-rate remained stationary; and in others, where plans of drainage had been carried out, the sanitary advantages, as regards phthisis, were nullified, because, as in the case of Carlisle, they were so low-lying that the subsoil was at all times more or less water-logged. So far, therefore, the relation between dampness of soil and phthisis, as one of cause and effect, became highly probable, and Dr. Buchanan's second inquiry converted the probability into a scientific certainty.

In this special inquiry (see *Tenth Report of the Medical Officer of the Privy Council*) the various registration districts in the three south-eastern counties of England, beyond the limits of the metropolis, were brought under detailed examination, and considered in two ways. Firstly, the true phthisis-rate of the population was ascertained, and due allowance made for the causes of the disease which were likely to influence the rate besides the nature of the soil; and secondly, the numbers of the population, in each district, that were found "living upon various kinds of soil, and under

various topographical conditions," were also noted. The results of these two separate lines of investigation were then brought together, and statistically compared.

Without entering into any of the geological details, which are fully given in Dr. Buchanan's report, it may be said, generally, that the dampness or dryness of a soil depends partly on whether, if pervious, it is retentive of water, or, if impervious, the water can readily drain away. Again, it is obvious that pervious soils may present very different degrees of dryness or wetness, according to the elevation of the ground, and the dip of underlying impervious beds. Thus, a stratum of gravel or chalk, covering a sloping bed of impervious clay, is necessarily a dry soil, because the rainfall readily sinks to and flows along the surface of the impervious slope, whereas the same stratum in a valley may be actually waterlogged, although the depth of the stratum may be the same throughout. Bearing in mind, then, the topographical relations as well as the physical qualities of different soils, the following general conclusions, given by Dr. Buchanan as the result of his inquiry, will be at once understood:—

"(1.) Within the counties of Surrey, Kent, and Sussex there is, broadly speaking, less phthisis among populations living on pervious soils than among populations living on impervious soils.

"(2.) Within the same counties there is less phthisis among populations living on high-lying pervious soils than among populations living on low-lying pervious soils.

"(3.) Within the same counties there is less phthisis among populations living on sloping impervious soils than among populations living on flat impervious soils.

"(4.) The connection between soil and phthisis has been established in this inquiry—

"(*a*) By the existence of general agreement in phthisis-mortality between districts that have common geological and topographical features, of a nature to affect the water-holding quality of the soil;

"(*b*) By the existence of general disagreement between districts that are differently circumstanced in regard of such features; and

"(*c*) By the discovery of pretty regular concomitancy in the fluctuation of the two conditions, from much phthisis with much wetness of soil to little phthisis with little wetness of soil.

"(5.) The whole of the foregoing conclusions combine into one—which may now be affirmed generally, and not only of particular districts—that wetness of soil is a cause of phthisis to the population living upon it."

It is interesting to note that this new discovery in the etiology of disease, which in this country has been associated with Dr. Buchanan's name, had already been brought to the notice of the profession in America by Dr. Bowditch, of Boston, U.S. It would appear, however, that Dr. Bowditch's researches were not known in England until after Dr. Buchanan's inquiry had been finished; and although the priority rests with him, the credit of independently establishing causation of phthisis by dampness of soil as a general law in this country remains with Dr. Buchanan. But it would be unfair not to quote Dr. Bowditch's own remarks. In a very able and lucid address delivered to the Massachusetts Medical Society in 1862, he submitted the two following propositions as containing the essential results of very extended inquiry:—

"First.—A residence in or near a damp soil, whether that dampness be inherent in the soil itself, or caused by percolation from adjacent ponds, rivers, meadows, marshes, or springy soils, is one of the principal causes of con-

sumption in Massachusetts, probably in New England, and possibly in other portions of the globe.

"Second.—Consumption can be checked in its career, and possibly, nay probably, prevented in some instances, by attention to this law."

But in addition to phthisis there are several diseases, such as rheumatism, heart-disease, and catarrhal complaints, which are intimately connected with dampness of subsoil, and it probably influences to a large extent the prevalence of other diseases. Thus Dr. Blaxall, one of the Local Government Board Inspectors, in a report on the prevalence of measles, whooping-cough, and pneumonia, in Swindon, has shown that these diseases were far more fatal in New Swindon than in Old Swindon; and he attributed the increased severity in the former place to the dampness of subsoil upon which the new houses are built, and the complete absence of precaution to prevent the ground air rising into the houses. New Swindon is built on kimmeridge clay, and was formerly much liable to floods. Old Swindon, on the other hand, stands 100 feet higher, and is built on limestone and sand. Indeed, the presumption would appear to be that in localities where climatic and topographical conditions are closely similar, dampness of subsoil would declare itself as an important agent in the development or spread of all diseases, which directly or indirectly affect the respiratory organs. Diphtheria, croup (not spasmodic), and pneumonia, are all of them diseases which have often been found to be associated with conditions of soil, such as dampness, or filth impregnation polluting the well water and ground air, and no doubt other diseases of the zymotic class, as, for example, erysipelas and pyæmia, are largely influenced by these important factors.

Concluding Remarks.—Although many valuable contributions have been made to the geographical distribution

of disease in different regions of the globe, very little of a concise and well-defined nature has been achieved so far as regards this country. Indeed, Mr. Haviland may be said to be the only writer who has investigated this subject with any approach to completeness, and even his results are open to the objection that the statistics on which he based his inductions often applied to districts which were much wider than the town or village dealt with. Thus it generally happens that a small town only forms part of what is called a registration sub-district, and in this wider district the topographical and geological conditions may vary greatly in different parts. But many of Mr. Haviland's generalisations are based on statistics which apply to large tracts of country, and so far they claim for themselves a certain value, but even then they are intimately associated with conditions which are purely climatic. The diseases which are especially investigated in his painstaking work on the *Geographical Distribution of Diseases in England and Wales* are heart-disease, cancer, and phthisis, and briefly summarised, his main conclusions are these :—As regards heart-disease and dropsy, statistics showed that the highest mortality districts are always to be found in the most sheltered spots, and are generally those which lie nearest on the leeward side to the sheltering range. He attaches great importance to the purifying influence of sea-winds, and further states that agricultural labourers, owing to poor living, low wages, and having to turn out in the early morning when the dew is on the ground, the air chill, and the exhalations of the night are most noxious, are especially liable to rheumatism and all its complications. No doubt their liability to rheumatic disease is greatly increased by exposure to wet, and having to live in cottages which often have damp floors and are built on undrained ground.

With regard to cancer, he found that in counties

having a high mortality from the disease, the tributaries of rivers flow from soft, marly, and easily disintegrated rocks into sheltered valleys through which the main rivers flow. During times of heavy rainfall these rivers invariably flood their adjacent districts, and have generally their waters coloured by suspension of alluvial matter. In all these respects the Thames valley is cited as a typical cancer field. Statistics also go to prove that cancer does not thrive on a high dry soil.

With respect to phthisis his conclusions generally bear out those already stated in connection with dampness of soil, namely, that damp clayey soil, whether belonging to the wealden, oolitic, or cretaceous formations, is coincident with a high mortality from this disease. Basing his conclusions on the statistics of wider areas, he further states that coincident with sheltered positions there is a low rate of mortality, and that the easterly ridges of the south-east coast of England are characterised by a high mortality, owing mainly to their general aspect being favourable to the malign influence of the east wind. This also applies to the eastern counties having a high mortality, while the lower lands are characterised by clays of the Eocene period, especially the London clay. He further found that high elevated regions of non-ferruginous carboniferous limestone, coal, and silurian formations, form the sites of the most extensive series of high mortality districts, and especially instances Anglesey. On the other hand, he states as a general rule that a warm, fertile, and ferruginous soil is coincident with a low mortality from phthisis.

CHAPTER XIII

DWELLINGS

THE vast importance attaching to the sanitary conditions of dwellings has already been frequently alluded to in previous chapters. Diseases arising from unhealthy site, from insufficient ventilation or overcrowding, from tainted or stinted water-supply, from defective drainage, or from accumulations of filth, are all of them associated with habitations which are faulty in their situation, construction, or management.

SECTION I.—SITE.

In choosing a site, special attention should be paid to the nature of the soil and the general conformation of the ground. Soils in order of healthiness may be approximately classed as follows:—Those overlying the primitive rocks, clay slate, millstone, grit and oolite, gravel and loose sands, chalk, sandstone, limestone, and clays. In cold and temperate climates, sands and gravels may be regarded as the healthiest, because they are warm and dry, but with cesspools or badly laid drains there is great risk of well pollution. The soil, if not dry, should be drained, and all hollows wherein water is likely to lodge should be avoided. For these and other reasons, the best situation for a house is on rising ground, with trees in the immediate neighbourhood, but not so close as to

interfere with the free movement of the surrounding air. The aspect will very likely be influenced in great measure by the view to be obtained from the front windows, but it is preferable that a house should face east or south-east, because in the morning the rays of the sun penetrate to the front rooms, and in the afternoon they cheer those at the back. When, on the other hand, a house faces south, the front rooms are overheated in summer by the rays of the noontide sun, while those at the back are deprived altogether of sunlight. Further, it is very essential in country districts that it be first ascertained that a good supply of wholesome water is procurable, and that there are no difficulties in respect to efficient drainage. If the subsoil is at all damp, it should be drained by suitable earthenware field-pipes, but care should be taken not to connect with house-drains unless under strict precautions as to disconnection and ventilation. (See Chapter X.)

In towns, a great evil sometimes arises from building on rubbish containing vegetable matter which has been used to fill up the excavations made in brickmaking. Household ashes and road scrapings have been often used for this purpose, and it need hardly be said that such sites should not be built upon until a sufficient period has elapsed, generally three years, for the nitrification and oxidation of all organic matters.

Indeed, if fæcal matters have formed part of the refuse, the model bye-laws of the Local Government Board enjoin that all such contaminated soil should be cleared away before building operations are commenced. They also specify that in all cases the whole ground surface or sites of new buildings should be properly asphalted or covered with a layer of good cement concrete, at least 6 inches thick.

In building on a site which has already been occu-

pied, great care should be taken to make a thorough examination of the ground, so that no cess-pits, rubble drains, or old wells may escape notice. Every old drain should be taken up, all removable filth cleared away, and every pit thoroughly cleaned out and filled in with concrete.

In order to secure sufficient ventilation around new dwellings the bye-laws further make it incumbent on all Sanitary Authorities invested with urban powers to provide for a free air space in front of at least 24 feet across, in other words, that this should be the minimum width of new streets not exceeding 100 feet in length; if the street is of greater length and used as a carriage-way, the minimum width specified is 36 feet. They also provide for an open space at the back of each dwelling amounting to at least 150 superficial feet free from any erection above the level of the ground, with the exception of closet or ash-pit. Such space should extend the whole length of the building, and at no point should it be less than 10 feet across to the nearest boundary of any premises opposite. If the height of the building is 15 feet, the minimum distance across should be 15 feet; if the height is 25 feet, it should be at least 20 feet across; and if the height is 35 feet and upwards, the minimum distance should be increased to 25 feet.

Section II.—Structural Details

The arrangements with regard to drainage of subsoil, house-drainage, closet accommodation, etc., have all been so fully described in a previous chapter (see Chapter X.), that it is not necessary to dilate further upon this part of the subject. Some further details may, however, be given with regard to points of construction as set forth in the model bye-laws :—

1. Except under certain prescribed circumstances in which timber framing is permissible, the outside and return walls of every dwelling must be constructed of incombustible materials, such as good bricks, stones, or other hard materials properly bonded and solidly put together with good mortar and good cement.

2. The footings of every wall must rest on solid ground, such as rock, or on a sufficient thickness of good

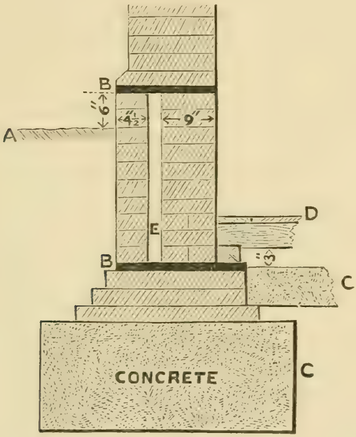


Fig. 22.—(From Annotated Model Bye-Laws.) A, Ground Level. B, B, Damp Courses. C, C, Concrete. D, Floor. E, Cavity between Walls.

concrete, and they should extend on each side to half the thickness of the wall and to a height of two-thirds of the thickness of the wall at its base.

3. If the whole of the building is above the ground level, every wall should be provided with a damp course of sheet lead, asphalt, vitrified stone-ware, or slates laid in cement beneath the level of the lowest timbers, and not less than 6 inches above the ground level.

4. When there is a basement storey, it should be isolated from the surrounding ground either by an open

area, or by constructing what is called a "dry" area. This consists of a thin outer wall bonded to the inner wall by stretching bricks, or iron ties, and with a hollow space between of at least $2\frac{1}{2}$ inches wide extending to a height of 6 inches above the ground. In this case two damp courses become necessary, one at the base of the wall, and the other at the level of the top of the captivity between the two walls (Fig. 22).

Although it does not fall within the scope of building bye-laws, it may be here pointed out that as much of the dampness in walls is due to driving wet, well-planned houses are now often built with hollow outside walls extending throughout. In single outside walls driving wet may be prevented by slating or tiling them, or by applying to the outer surface one or other of the several water-proof compositions which are well recommended.

5. The minimum thickness of all external or party walls specified is 9 inches, and in large buildings it must be increased according to their height and length. Thus, if a wall does not exceed 30 feet in length, and does not comprise more than two storeys, it should be 9 inches thick for its whole height. If, however, the wall exceeds 30 feet in length, or comprises more than two storeys, it should be $13\frac{1}{2}$ inches thick below the topmost storey, and 9 inches thick for the rest of its height. Full regulations are given for thickness of walls of greater heights and lengths.

6. In order to prevent the spread of fire, all party walls should be continued up through and above the roof to form a parapet of a specific height, according to the class of building, and for the same reason no bond timber or wooden joists should be inserted in party walls. The roofs themselves should be made of slates, tiles, or other incombustible materials, and the gutters or shoots to carry off the rain-water should also be incombustible.

7. Wherever the lowest storey of a house has a boarded floor, it is very essential that there should be free ventilation between the wooden floor-joists and the surface of the concrete or asphalt which is laid over the ground to keep out the ground-air. It is therefore specified that there should be a space at least 3 inches high between the asphalt or concrete and the joists, and that this space should be efficiently ventilated by the insertion of air-bricks in the outer walls. If such ventilation is insufficient, the air becomes damp and musty, and the joists and flooring are apt to be attacked with dry-rot.

8. Although unfortunately there is no prescribed minimum height for rooms, they should, as a rule, be at least 8 feet 6 inches high, even in the case of small rooms, and for average-sized rooms the minimum should be 10 feet. Power, however, is conferred by the Public Health (Amendment) Act, 1890, to make bye-laws with respect to height of rooms, as well as construction of floors, hearths, and staircases.

9. In order to secure sufficient light and ventilation, it is specified that every habitable room shall have at least one window opening directly into the external air, and the total area of the window-space should be at least equal to one-tenth of the floor-space. It is further specified that every window should be constructed so that one-half, at the least, may be opened, and also that the opening may extend in every case to the top of the window. It will, therefore, be seen that this regulation permits of either double-hung sashes, French casements, or sashes hung on hinges or pivots.

10. Another important bye-law specifies that every habitable room which is without a fireplace and chimney, must be provided with special and adequate means of ventilation by a sufficient aperture or air-shaft, which

should give a free sectional area of at least 100 square inches. (For further details as regards ventilation, warming, and lighting, see Chapter IV.)

Such is a brief summary of the more important structural details which are laid down in the model bye-laws of the Local Government, but unfortunately a great many sanitary authorities prefer to work under antiquated bye-laws, alleging as a reason that revision in accordance with the new model bye-laws would heavily handicap builders, especially in respect to the additional expense required for foundations and the thickness and height of party-walls. It need hardly be said, therefore, that jerry-building is still allowed free play in many towns, and even the erection of unhealthy back-to-back houses is not yet universally prohibited. It is unfortunate, too, that the great majority of rural districts throughout the country have no control over new buildings, except in respect to the provision of water-supply, so that glaring defects as regards house-construction, drainage, and closet accommodation are in a large measure perpetuated.

Section III.—Dwellings for the Working Classes.

In constructing buildings for the labouring classes the great difficulty, encountered at the very outset, consists in providing the necessary accommodation with the requisite sanitary arrangements at a cost which will allow of a sufficiently low rental. In towns the original cost is enormously increased by the high price of land; but even in country places, where a site can be procured at a cheap rate, the cost for the erection of a cottage of the humblest pretensions will entail a rental which many a labouring man can barely meet. Where the ground-rental is low, the cheapest and most commodious form of labourer's cottage is one without any upper storey. Thus, according

to Mr. Allen, in his manual on Cottage Building, a cottage consisting of a living-room for general everyday use, a bedroom for the labourer and his wife, a bedroom for boys, a bedroom for girls, a small wash-house, a storeroom and closet, could be built for £100, provided all the rooms are on the ground-floor, and that two such cottages be ranged side by side, so as to be spanned by the same roof, and contained within four walls, forming a simple parallelogram.

In a paper read before the Farmers' Club in 1874, Mr. Howard of Bedford states that, some few years previously, he built a block of six cottages for his labourers entirely of concrete. The walls were a foot thick, and in consequence of the impervious nature of the material they were warmer and drier than ordinary brickwork. Each cottage contained three bedrooms, and each was provided with an earth closet at the end, but accessible from within. Exclusive of the closets, the cost of the whole block was a little over £600, or £100 per cottage.

Owing to the increased cost of materials, and the rise in wages, it is very likely that the above estimates would be found to be somewhat too low for the erection of similar cottages in the present day, but if built in blocks or pairs, I am credibly informed that good cottages with three bedrooms can still be erected for about £120.

In these plans, and in fact in almost all plans for cottage construction, the cubic space allowance is very limited, so that overcrowding to a greater or less extent is sure to prevail at times. Cottages which are scarcely roomy enough for a married couple with two or three children become occupied by much larger families, or the family increases in number year after year, while the bedroom accommodation remains the same. The initial space, therefore, should be ample enough to meet the requirements of, at any rate, moderate family increase; and when a number of such cottages are built in the same locality,

they should be of different sizes, to suit small and large families alike.

In large towns the house accommodation for the labouring classes must necessarily be supplied in a great measure by what are called tenements, but in this case special attention should be paid to sanitary arrangements, such as closet accommodation, water-supply, ventilation, and general cleanliness of premises, and a copy of rules or bye-laws should be prepared and handed to each occupant.

In the block system, the buildings as a rule should not exceed four storeys in height, and there should be a free open space on both sides of the blocks with a playground for the children. As few families as possible should be located on the same flat or landing. The staircases should be fire-proof, be at least four feet wide, and well-lighted by large windows, and their walls and the walls of landings should be lined with glazed bricks or smooth cement. The closets and dust shoots should be erected in projecting wings or offshoots from the main buildings, and a sink with water laid on should be provided for each dwelling. It is also necessary that there should be a sufficient number of wash-houses, and these are sometimes placed on the roof. If the blocks are built in quadrangles or squares, there should be free open spaces at the corners of the enclosed space to ensure sufficient ventilation.

Of equal importance with the construction of dwellings for the labouring classes is the far more difficult problem of repairing and improving the unhealthy abodes which, in town and country village alike, increase the annual rate of mortality to an extent that can hardly be estimated. It is to be hoped, therefore, that the carrying out of the provisions of the Housing of the Working Classes Act, 1890, will soon effect a marked improvement in this respect in many of our cities and large towns, for

hitherto the difficulty of dealing with what is called "surface-crowding" has thrown great obstacles in the way of reaping to the full extent the advantages to be gained from lessening the indoor overcrowding. Demolition of old houses, the displacement of the population into blocks of model dwellings, or into houses put into serviceable repair, and the opening of new streets, are all necessary.

Concerning the duties of medical officers of health with regard to overcrowding and houses unfit for human habitation, see concluding Chapter.

Section IV.—Sanitary Inspection of Dwellings.

1. *Diseases traceable to Sanitary Defects.*—There are so many diseases, and some of them so fatal, associated with sanitary defects in or around dwellings, that it is of the utmost importance that every medical practitioner, and above all every sanitary official, should be able to detect these hidden dangers, or direct how they may be discovered and remedied. Exclusive of new houses which have been erected in accordance with well-devised bye-laws, it is no exaggeration to say that in the vast majority of houses, and especially good-class houses, sanitary defects may be found which at any time may lead to the gravest consequences, and when disease does break out the wonder often is that the inmates should have escaped so long. Minor disorders, such as languor, headache, so-called bilious attacks, dyspepsia, diarrhœa, and slight ulcerated sore throat, are frequently allowed to pass unheeded, or are treated as ordinary ailments; and it is not till disease of more pronounced severity occurs that the sanitary condition of the house becomes suspected, and the real cause is discovered.

Apart from ailments which are connected with dampness of site, foundations, or of walls, such as rheumatism,

phthisis, bronchitis, or other lung affections, the class of diseases which are associated with faulty house sanitation are essentially filth diseases, whether they originate *de novo* or are conveyed by befouled air or water. And among these diseases may be enumerated the following:—diphtheria, ulcerated sore throat, follicular tonsillitis, follicular stomatitis, croup, enteric and ill-defined forms of fever, diarrhœa and dysentery, erysipelas, carbuncle, abscess, pyæmia, hospital gangrene, and puerperal fever. There is no doubt, too, that the breathing of vitiated air, whether depending upon overcrowding, defective ventilation, or the entrance of sewer-gas, not only induces phthisis, pneumonia, and other lung affections, but largely influences the spread of zymotic disease and the severity of all kinds of diseases, however they may have been originated in the first instance. Pneumonia is frequently engendered by impure air, and it is now generally admitted that this filth-pneumonia, as it may be called, is infectious, and occasionally becomes epidemic. Then, again, there can be little doubt that it is this influence which changes pleurisy into empyema, simple bronchitis into broncho-pneumonia, and which serves to explain the frequency with which lung affections are associated with various infectious diseases, such as smallpox, measles, whooping-cough, and enteric fever.

2. *Sanitary Defects in and around Dwellings.*—As regards the defects themselves, they are of every variety and extent, and many of them palpable enough. Damp foundations, damp walls, imperfect ventilation, windows not made to open, roofs dilapidated and out of repair, floors uneven, general uncleanliness, overcrowding—all these constitute nuisances which are especially common in the dwellings of the poorer classes in town and country districts alike. Then, if there is no sink inside the dwelling, there is generally a drain near the front or

back door to remove the slops, which is so badly laid and trapped that foul smells are constantly given off, and these are often aggravated by other nuisances. In country districts, for example, pig-styes, byres, and manure-heaps are frequently so close to the dwellings that the inside air is always more or less tainted. The closet accommodation, again, consists either of a foul privy, which, though sufficiently far removed, is so offensive that it cannot be used without risk, or of a privy and deep ash-pit close to the house and in dangerous proximity to the well. Indeed, pollution of the well-water from closets, leaky drains, or manure-pits in farm-yards is the principal cause of the majority of the sporadic cases of enteric fever which are met with in country districts, and of much of the diarrhœa which becomes more or less prevalent during dry and warm seasons. Apart from overcrowding, then, it may be said that the gravest dangers to health connected with the dwellings of the poorer classes in rural and small urban districts are external rather than internal, and therefore it is essential that in making a systematic inspection of such premises special attention should be paid to the surroundings. The points to be noted on a detailed inspection are the following:—Date of inspection; name or situation of house; name of owner and occupier; number of inmates; number of lodgers, if any; number of living-rooms and sleeping rooms (if overcrowding is suspected, the cubic space of the sleeping-rooms should be ascertained); state of ventilation (note whether all windows are in good repair and are made to open, and whether every sleeping-room not provided with a fire-place has a ventilating opening of some sort in addition to window); conditions of floors and staircases (whether they are uneven or out of repair); condition of walls (whether damp or dilapidated); condition of roof

(whether it lets in the wet); general condition of premises (whether clean and in good repair); general condition of yards or courts (whether clean and properly paved); condition of drainage and spouting (if any drain enters the house, note whether it is properly intercepted outside, also note whether outside drains are well laid and properly trapped, and whether roof and surface water is properly conveyed away); nature of water-supply (if from a well, note whether there are any sources of pollution near, such as deep ash-pit, privy, cesspool of any kind, leaky drain, or manure pit—if water is suspected, have it analysed); nature, situation, and condition of closet accommodation (note whether closet is free from nuisance, whether there is a deep ash-pit in connection with it, whether, if not a pail-closet, it is situated at a safe distance from house or well, etc.); other nuisances (such as keeping of pigs too near dwellings, pig-wash cisterns, manure-heaps, etc.)

In inspecting the poorer dwellings in the crowded parts of large towns, special attention should be given to the free space back and front, and back-to-back houses should be carefully examined and noted. The condition of the courts, streets, lanes, or back-yards should also be closely inspected in respect to paving, ventilation, lighting, and general cleanliness. The condition of outside closets, ash-pits, etc., should receive particular attention, while the details of the inspection of the houses themselves should be noted as already described, but special attention should be given to cellar-dwellings, and in all cases the water-supply and the condition and situation of water-cisterns should be carefully inquired into.

With regard to country mansions and the better class country houses, the dangers to health, if not more numerous, are certainly more serious, and for the most

part are connected with the drainage or water-supply. Indeed, it is no exaggeration to say that grave sanitary defects will be found to exist in almost every country residence which has not been built or inspected within the last ten years; and even in respect to new buildings it is lamentable to find that, owing to ignorance or neglect on the part of architect, contractor, or plumber, and sometimes of all three, the most serious blunders are still perpetrated.

One of the chief dangers in country houses attaches to the cesspool and the drains leading to it. The cesspool itself is generally some distance from the house, and is provided with an overflow which discharges into the nearest ditch or brook. It is rarely ventilated, but is usually completely covered up, and in any case is only cleaned out at long intervals, sometimes not for periods of years, and, to add to the danger, there is no disconnection by syphon-trap and ventilated manhole between it and the house-drains. The drains are frequently either rubble drains, sometimes huge brick culverts, or common tile drains; but, whatever their exact structure, they permit of free deposit, and are neither efficiently trapped nor ventilated. In close proximity to the walls, and sometimes under the floors, there are frequently supplementary cesspools or catch-pits, intended to retain solid matters, which are kept covered up with close-fitting slabs, and are so seldom opened and cleaned out that their very existence becomes forgotten. Into this system of drainage are discharged directly the pipes from sinks and sculleries, the overflow-pipes from baths, the drains from cellars, the soil-pipes from water-closets, and very often the rain-water pipes.

The water-closets are generally situated somewhere in the centre of the house, badly lighted, badly constructed, and without proper ventilation. The soil-pipes are

unventilated, and very soon become decayed and perforated. Very often the cistern supplying the closet is filled by means of a force-pump; and the same cistern, which is rarely cleaned out, and from which there is an overflow-pipe leading direct into the soil-pipe, also supplies the water for drinking and cooking purposes. In addition to all these sources of danger, the well itself may be close to one of these leaky drains or cesspools, or it may be near some outside offices of the worst form of privy or midden ash-pit, so that in any case it is constantly exposed to the risks of pollution.

In town houses of old construction the dangers to health are similar, though perhaps not so grave, inasmuch as the water used for domestic purposes is usually obtained from a public supply. But even this may become contaminated in the house-cistern if the overflow-pipe from the cistern, as often happens, discharges directly into the soil-pipe or the house-drain, or if the same cistern directly supplies the water-closet. The drains, for the most part, are laid underneath the house, and are often found to be constructed of brick, and generally so leaky that the sewage percolates into the soil. In houses infested with rats it may be taken for granted that the drains are brick drains, or at all events that they are of very faulty construction. Even when drain-pipes have been used, they are frequently so badly laid and jointed that soakage into the soil becomes constant, and the inside air of the house always more or less contaminated. The closets, again, are generally of faulty pattern, and very improperly situated—it may be, in the centre of the house, on the landing, or sometimes in the bedrooms themselves; but in any case they are almost always badly lighted and ventilated. The soil-pipes, as in country houses, are usually inside the house, often very leaky, and seldom ventilated, nor are any other means of venti-

lation provided for the house-drains. Moreover, the waste-pipes from sinks, baths, and cisterns are often not properly disconnected, so that channels for the entrance of sewer-air are to be found on every floor of the house, but especially in the basement, where, in addition to the leakiness of the drains, there are openings into them for the purpose of washing down the floors or draining cellars. These drain inlets are a permanent source of danger, because the traps are often bell-traps, from which the water evaporates, leaving practically untrapped openings; or if the water does not evaporate, the pressure of sewer-gas is so great that the water becomes tainted, and is constantly giving off foul emanations. Another common source of danger depends upon the direct connection of the over-flow pipe from the soft-water tank or well with the house-drain, and which not only taints the water in the well, but becomes a channel for the entrance of sewer-air into the house. Sometimes it happens that foul smells are detected in parts of a house where there are no drains or inside pipes discharging into them, and in these cases it is generally found that the foul air travels along rat runs, under floors, or behind skirtings; or it may be conveyed along the pipes containing the bell-wires; or it may find an entrance through the windows, from an adjacent rain-water pipe which is directly connected with the sewer. Of course foul smells in a house do not always indicate the entrance of sewer-air, but they should never be tolerated a single day until the cause is ascertained and removed. Sometimes they are caused by the decaying body of a dead rat or mouse under the flooring, by dry rot, or, in rare instances, they have been found to proceed from some filthy paste used in papering the walls; but as a rule they point to defective drainage or escape of sewer-gas into some part of the house.

3. *Mode of Inspection.*—In making a detailed examination of the sanitary condition of a large house, it is advisable that either an experienced builder, whose practical knowledge can be relied upon, or a sanitary engineer, be called in; and if there are plans of the house and drainage in existence, these should be obtained. In order to make the examination as thorough as possible, arrangements should be made to have the drains previously opened in several places, and concealed pipes and other fittings exposed to view. If the main drain is found to pass under the house, and to be badly laid or constructed, the instructions should be to have it taken up and relaid. Should it appear to be in good condition, it should then be tested as to its soundness, which is done by stopping it up at its lower end and filling it with water, and noting whether the water sinks or not, and at what rate. To test whether there are any deposits, a large volume of water should be poured down at the water-closet or sink, and if this appears foul and thick at the lower opening the drain is condemned as one of deposit. By noting the time which intervenes before the rush of water appears at the lower opening, an approximate idea may be obtained of the velocity of flow, or this may be determined with greater precision by pouring down some lime-water, and timing the flow. Leakages in the pipe-tracks or elsewhere, for the escape of sewer-gas, may be detected by first pouring down some oil of peppermint and afterwards some hot water at the closet or sink, or, better still, blowing up at the opening made in the drain the smoke from an asphyxiator or using smoke rockets. If the soil-pipe is ventilated, it is essential that it should be stopped up at the top when the smoke test is applied. For ready testing, an opinion as to the condition of the drainage can often be given at short notice, by lighting and inserting a smoke-rocket into the drain

opening in a bell-trap, or by mopping out an ordinary gully trap, and inserting the lighted smoke-rocket into the trap, and then effectually closing the trap.

The next point which should be ascertained is whether the house drain is properly disconnected. As already shown in the bye-laws laid down for the drainage of new houses, this disconnection of the house-drain by trapping, and providing a ventilating opening on the house side of the trap, is of the utmost importance, and it can readily be carried out in all cases, either by providing a ventilating pipe if the house is close to the street, or a simple open grating if there is sufficient space. (See also Chapter X.)

Before leaving the basement, all traps and branch drains should be carefully examined, and a careful search should be made for cesspools, if the existence of any is suspected. The condition of the flooring should also be noted as to dryness or otherwise, and the ventilation of all parts of the premises should be inquired into. Any water-closet on the basement which is found to be in the centre of the building, or to abut against any inside wall, should be condemned. Such closets are badly lighted and ventilated, and the drains leading from them are usually very defective, and liable to be choked up. If there are no underground cellars or basement, inquiry should be made as to whether the space beneath the floors is sufficiently ventilated, and whether there are any signs of rot. The dust-bin or ash-pit, and any outside offices, should also be examined, and if the ash-pit is found to be large and deep, it should be filled up to the ground level.

The details to which attention should next be directed are those connected with water-closets, sinks, baths, etc. If the closet is in the centre of the house, or abuts against an inside wall, there can be no doubt of the faultiness of the arrangement. But even when the closet abuts against

an outer wall the soil-pipe generally leads down inside the house into the drain, and not infrequently is taken through cupboards or larders. The track of the pipe should be exposed to view, and its soundness tested, by means of filling it with water or by the smoke test; but it is advisable to recommend, in any case, that the soil-pipe should be carried outside, and be ventilated by a pipe of the same dimensions extending to above the eaves. Small ventilating pipes, of about $\frac{3}{4}$ in. or $1\frac{1}{2}$ in. in diameter, are practically of little use, and often become choked up. The woodwork and fittings of the closet should next be examined, and any overflow-pipe from the safe should be made to discharge outside. If the pipes from sinks, lavatories, and baths are not disconnected—and it is seldom found that they are, except it be in new houses—instructions should be given to have all these pipes carried outside the walls of the house, and made to discharge on to trapped gratings communicating with the drain. Rain-water pipes which are found to be directly connected with the house drains should also be disconnected, and any found passing inside the house should be carried outside.

The cisterns which supply the closets should next be examined, and it should be ascertained whether these supply the drinking water as well. If the water is stored in a large cistern under the roof, and is found to supply any taps, each closet supplied from this cistern should be provided with a small waste-preventing cistern, or steps should be taken to provide an independent supply for drinking and cooking directly from the main. The cistern itself should be examined as to cleanliness, and the overflow-pipe, which is often found to lead directly into the soil-pipe, should be carried outside. Soft water cisterns or tanks should also be examined, because it frequently happens that the overflow-pipe is directly connected with the house drain. This pipe should

be properly intercepted by a ventilated intercepting syphon-trap.

In all houses provided with a public supply the use of well water should be condemned, because, although it may be found to be fit for drinking purposes, the risk of pollution is always greatly increased in towns, on account of neighbouring drains and sewers. In country districts special attention should be directed to the water-supply, and any deep ash-pits, midden-privies, or cesspools near wells should be removed, and the drains examined. If the water is pumped up by means of a force-pump into a cistern, for the purpose of supplying the closets, it will generally be found that the cistern also supplies the housemaid's sink, and that at this tap the water-bottles, as well as bedroom utensils, are usually filled.

If an entire new system of drainage is deemed necessary, all old drains, polluted subsoil, cesspools, etc., should be cleared away, and the details and sanitary appliances generally should be carried out as already described in Chapter X.

Although much improvement has been made of late years in the sanitary arrangements of dwellings, it should be laid down as a rule by every tenant in search of a house, that he should have the sanitary condition carefully inquired into, and any defects removed, before he takes possession. In London, Edinburgh, Gloucester, and several other large towns there are Sanitary Protection Associations which undertake such inspections, and repeat them at stated times for a fixed fee or subscription; but it would be a wise policy on the part of Sanitary Authorities throughout the country to undertake these duties themselves, and not limit their functions to the removal of actual nuisances, without interfering with many defects which only become declared nuisances when disease breaks out.

CHAPTER XIV

HOSPITALS

In large towns the position of every hospital must primarily depend on the distribution of the population, or part of the population, whose wants it is intended to relieve, and hence the choice with regard to site is often very limited. Apart, however, from this restriction, there are certain considerations which ought always to influence the selection of site. For example, the future hospital should be erected in as airy and open a space as can be obtained, preference being given either to the outskirts of towns or to their largest interior unoccupied spaces. In this country an acre per 100 patients has been held to be sufficient, but a good deal will depend on the size of the hospital. Any defect in airiness of site must be compensated by increased floor and cubic space.

No doubt, the most healthy sight for a hospital is in the open country, with a dry and porous soil, and slightly raised above the plain to facilitate drainage, but even a stiff clayey soil can be made perfectly healthy if proper precautions be taken in asphalting or concreting the foundations, and in providing plenty of free ventilation beneath the ground-floors by building on arches. While shelter from the cold north-easterly winds is desirable, it is an error to build hospitals on the face of a steep slope, or in any situation where there is an impediment to a free circulation of the air. Whether in town or country,

the blocks should, if possible, be so arranged in a north and south-westerly direction, that the ward windows on each side should face south-east and north-west respectively.

For hospitals situated in the crowded localities of large towns, convalescent homes in the country, or at the seaside, are now being provided, and with marked advantage to the patients.

It is now generally admitted that, when large hospitals are rendered necessary, they should approximate as much as possible to the sanitary conditions which can only be ensured by detached buildings. The application of this principle has resulted in the construction of hospitals on the pavilion system—a system which accommodates itself to almost any site and to any number of patients.

Section I.—Pavilion Hospitals.

In this description of hospital, each pavilion may be regarded as a separate hospital, and the impurities of every single ward are cut off from the other wards. The pavilions are united by a corridor for administrative purposes and for convenience, but are so arranged that a free circulation of air can always take place between them. In its simplest form a pavilion would consist of a single ward, with the necessary additions for administration. More frequently, however, it consists of two wards, one above the other, and, in some instances, of three wards, as in the Marine Hospital at Woolwich. Three-storied pavilions are objectionable, because unless special precautions are taken their height necessitates a lofty corridor to unite them, and induces stagnation of the air. With two-storied pavilions, on the other hand, the corridor need only be half the height of the pavilions. In large hospitals, such as the Herbert Hospital, the pavilions may be united in twos, end to end, with the

corridor running between them, the staircase being, as it were, strung on to the corridor. But care must be taken that staircases or lifts should not act as air-shafts, by which the air from wards below can communicate

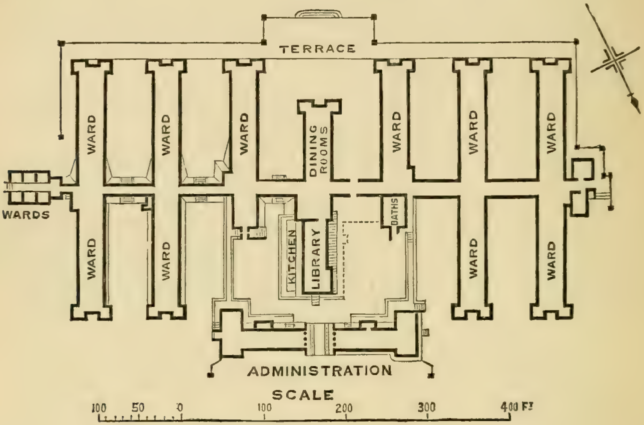


Fig. 23.—General Plan of Herbert Hospital, Woolwich. (From *Construction of Hospitals*, by Douglas Galton.)

with above wards. Corridors, therefore, should be freely ventilated by cross ventilation, and it is preferable that

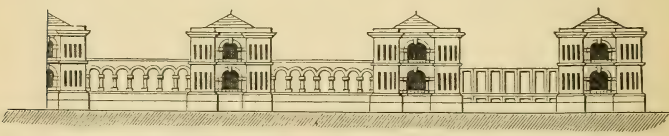


Fig. 24.—Sketch of the end of the southern Pavilions of Herbert Hospital, showing the elevation of the Corridor. (After Galton.)

they should only be covered. The distance between the pavilions should be at least twice their height.

The basis or unit of hospital construction is the ward. The conditions which determine the size and form of a ward are the following:—

1. The number of patients which it should contain.

2. The floor and cubic space allowed to each patient.

3. The arrangements for warming, light, ventilation, and nursing.

1. The number of patients in a ward will depend on the size of the hospital, and, occasionally, on the nature of the cases. A cottage hospital, for example, will necessarily consist of small wards, and even in large hospitals small wards are required for isolating very severe or special cases. With these exceptions, however, the number of patients in a ward must depend mainly upon the number which can be efficiently nursed at the smallest cost per head. Miss Nightingale, in the Report on Metropolitan Workhouses, fixed this number at thirty-two, but with severe cases this number is excessive. Throughout European hospitals the number varies from twenty-four to thirty-two.

2. One of the most important questions attaching to hospital construction is the amount of floor and cubic space which should be allowed to each patient, and there is scarcely any question concerning which there has been so much discrepancy of opinion. Without entering into the details of this controversy, it may be said that for ordinary hospital cases it is now generally admitted that a cubic space of at least 1200 feet should be allowed per patient, and for cases of infectious disease, or for severe surgical cases, as much as 2000, and it may be doubted if this be sufficient at all times.

On the superficial area per bed will depend the distance between the beds, the facilities for nursing, and the conveniences for ward administration. This, like the cubic space, has been variously estimated. Thus, in St. George's Hospital it is only 69 square feet; in St. Bartholomew's it is 79; in the Herbert Hospital, 99; in the Netley Hospital, 103; in Guy's, 138; and in the new St. Thomas's Hospital, 112. For all nursing pur-

poses, Miss Nightingale maintained that at least 90 square feet should be allowed per bed, and this amount, according to Sir Douglas Galton, should be accepted as a minimum. Where medical schools are attached to hospitals, an extra allowance must be allotted for the requirements of clinical teaching. The space must also be greatly increased in fever or lying-in wards. The height of an average-sized ward should be 13 or 14 feet.

3. For providing sufficient light and for maintaining purity of the air, much depends on the width of the ward. Experience has shown that this should not be less than 24 feet, and not more than 30 or 35. In the new Leeds Hospital it is 27 feet 6 inches; in the new St. Thomas's 28 feet; and in the Herbert Hospital 26.

The ventilation of each ward should be entirely independent of the others, and to effect this, cross-ventilation by means of open windows, aided by air-inlets, extraction-flues, and ventilating fire-places, is deemed to be the most efficient. In the summer months, when fires are not required, the windows should always be kept more or less open, except during rough, blustering weather.

When a window is allowed for each bed, which is sometimes the case, the wall-space between the windows should be 6 or 8 inches wider than the bed. In the pavilion system, however, an allowance of one window for every two beds is generally considered sufficient, the beds being arranged in pairs between the windows, and separated from each other by a distance of at least 3 feet. The windows should reach from within 2 feet or 2 feet 6 inches from the floor to within 1 foot from the ceiling. The space between the end wall and the first window on either side of the ward should be 4 feet 6 inches, and the space between the adjacent windows 9 feet, the windows themselves being 4 feet 6 inches wide. An end window to a long ward

adds greatly to its cheerfulness, and aids materially in the ventilation of the ward. The ordinary sash window made to open at top and bottom, with a fall in or hopper window above, is perhaps preferable to any other kind. To economise heat, plate-glass should be used instead of ordinary glass. To thoroughly ventilate the corners of wards a narrow window should be provided at each corner between the beds and the return walls.

In addition to means of ventilation provided by windows, there should be a fresh-air inlet, preferably Ellison's radiating ventilator, at the back of each bed on the floor level.

The extraction-flues, when not contiguous with a chimney, should be provided with gas-jets to aid their extractive power. If the fire-places are situated in the centre of the ward, the extraction-flues should be placed alongside the flues and separated from them by iron plates. The inlets to extraction-flues ought to be near the ceiling.

The fire-places best suited for infirmary wards are the ventilating stoves with open grates back and front, and situated in the centre of the ward and with flues passing under the floors and up the opposite walls. But in addition to these, or in place of them, the fresh air might also be heated by hot-water pipes.

Every gas-jet in a ward should be furnished with a bottomless lantern, communicating with an extraction-tube, to carry off the products of combustion, or ventilating globe lights should be used. (For particulars with regard to ventilation, see Chapter on that subject.)

The furniture in a ward ought always to be reduced to a minimum, and should never be cumbrous or bulky. Iron bedsteads are to be preferred to wooden ones, and thin horse-hair mattresses, placed on springs, or on woven wire mattresses, to thick flock or woollen mattresses. All bedsteads should be ranged at a short distance from the

walls. Coverlets and blankets should be white or light-coloured, to show dirt, and ought to be frequently aired.

The other points of sanitary importance connected with a ward are its offices, and the materials employed in construction.

Ward-offices are required for facilitating nursing, and for the direct use of the sick. Thus every ward should have attached to it, at the end nearest the door, a scullery and a nurse's room, and at the farther end a water-closet and ablution-room. The nurse's room should be light and airy, and large enough to be used as a bedroom. It should also be provided with a window, looking into the ward, for purposes of inspection. The scullery should be situated opposite the nurse's room, and ought to be

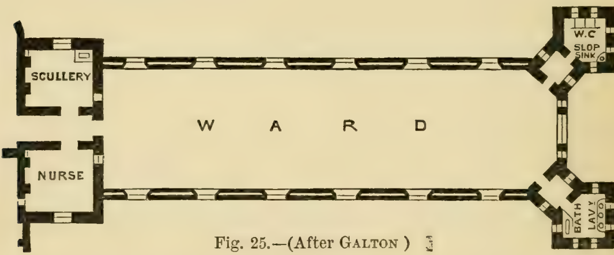


Fig. 25.—(After Galton.)

fitted with a small range for warming drinks, preparing fomentations, etc.; a sink with hot and cold water laid on; and shelves and racks for dishes.

The water-closet and ablution-room should be situated, one at either farther corner of the ward, and both should be completely cut off by means of swing-doors and a lobby supplied with cross-ventilation from the ward. The water-closet apartment ought to contain one closet for every ten beds, or three closets for thirty-two, and should also be supplied with a sink and a urinal. Instead of a handle and plug for turning on the water for flushing, it

is preferable to have a self-acting water-supply connected with the door, because some patients are careless, and others are too feeble to raise the handle.

The ablution-room should contain a plunge-bath with hot and cold water laid on, a shower-bath overhanging the broad end of the plunge-bath, and a lavatory table fitted with basins, and also supplied with hot and cold water. There should likewise be room enough to contain a portable bath on wheels, a hip bath, and a foot-bath for the use of patients more or less bedridden. The pipes leading from the sink and lavatory table should not be boxed in, because the spaces thus enclosed become receptacles for dirt.

The supply of water should be ample, and the drainage and sewerage perfect. All closet-pipes should be ventilated and placed against outside walls, and all other pipes disconnected from the drains. The various fittings should be of a light colour, to show dirt, and thus ensure thorough cleanliness. The walls of closets and ablution rooms should be lined with glazed tiles.

With regard to the materials of ward construction, it is now strongly recommended that the framework of the floor should be formed of iron beams, with the spaces between filled in with solid concrete, and that the floor itself should be made of the hardest wood, such as oak or teak, well jointed and treated by the paraffin process. The walls should be lined with Parian cement, or well plastered, periodically cleaned, and distempered; and the ceilings should be plastered and whitewashed, or distempered a light colour. All angles, whether horizontal or vertical, should be rounded, and the same principle should be applied to door-panels, window-panes, and ward furniture.

A ward thus constructed and arranged is in itself a small hospital, and the aggregation of ward units will

depend on the number of patients to be accommodated.

In an average-sized hospital the administrative buildings occupy considerable space, and may be variously distributed. All of them, however, must be made entirely subservient to the requirements of the sick, and should not interfere with the ventilation of the wards. Usually the administrative buildings are as follows:—

Kitchen, provision-stores, and stores for bedding and linen. These should be central. The kitchen should be situated on the top of the buildings.

Apartments for house-surgeon, matron, and servants; consulting-room, waiting-room, surgery, drug-store, and operating-room; all of them more or less central.

Laundry, mortuary, post-mortem room, disinfecting-room. These should all be detached from the building.

Nurses should have well-ventilated bedrooms, either in a separate block, or at the top of the central block, with all the necessary appliances for ablution, etc.

The staircases for patients should be broad and easy, and should be cut off from the connecting corridors by swing-doors. The corridors themselves should be as low as possible, well-lighted and ventilated. It is sometimes advantageous to construct all staircases and lifts in the central block.

The administrative buildings take up about half the cubic space of the whole hospital. As very good examples of the pavilion form of hospital on the small scale, may be mentioned the Royal Hants County Hospital at Winchester, the Buckinghamshire County Hospital at Aylesbury, and the New Hospital at Swansea. Amongst average-sized hospitals, the Great Northern Hospital at Holloway, designed by Messrs. Keith Young and Hall, may be instanced as illustrating all the most recent improvements in hospital construction.

With regard to the cost of pavilion hospitals, Sir Douglas Galton is of opinion that, with care and attention to economy in the design, a hospital for in-patients only, and built on a favourable site, should not cost more than from £90 to £120 per bed. The Leeds Hospital, which accommodates 350 patients, cost £197 per bed; the Royal Hants Hospital, with 108 beds, and including accommodation for out-patients, cost £229; and the Swansea Hospital, also including an outside-patient department, cost £142 per bed. Hospitals consisting of circular wards, as at Greenwich and Antwerp, have been advocated by some, but it is doubtful whether they possess any advantages over the pavilion system.

Day-wards, exercising grounds, and flower or winter gardens, are great additions to the sanitary advantages supplied by a well-constructed hospital. In summer, all the patients who are able to move about, and, indeed, most of those who are bedridden, should be allowed to remain during some part of every warm day in the open air. The flat roofs of the corridors, protected by awnings, could be utilised for the bedridden patients of the upper wards, while the corridors themselves might be appropriated by the same class of patients belonging to the lower wards. At the Great Northern Hospital, Holloway, the roofs of the pavilions are flat, so that they can be used as airing grounds, and large verandahs are provided at each ward level. With very little extra expense the corridors could be converted into winter gardens during the colder months of the year, and might be occupied by patients in the daytime without interfering with any of the administrative arrangements.

SECTION II.—COTTAGE HOSPITALS.

The cottage hospital system, originated by the late Mr. Napper of Cranleigh, is based on the principles of providing hospital accommodation for the sick poor of rural districts, with as much of the surroundings of home as possible; of permitting equality of privilege to subscribers in recommending patients, the patients themselves paying a certain sum weekly, according to their means; and of allowing any medical man practising in the district the use of the hospital for deserving cases under his care. The model cottage hospital should not have more than twenty beds, and must be under the management of one medical man as director, appointed either permanently or by rotation, the other medical men in the district holding office as honorary medical officers. The annual cost of the establishment is defrayed chiefly by voluntary contributions and partly by the weekly payments of the patients. These weekly payments, as already stated, are regulated by the means of the patient, and vary from 2s. 6d. when the Union has to help, to 5s. or 8s. when the patient has been earning fair wages, or belongs to a club. All fees allowed by the Union for accidents or operations are paid to the Union medical officer, in the same way as if he had attended the patient at his own home. Every subscriber, no matter what the amount of his subscription, should have equal privileges in recommending cases, and will generally be able to state what amount the patient whom he recommends can afford to contribute weekly. Cases of accident and emergency are admitted without order, but otherwise a recommendation from a subscriber must be procured, and this should in all instances be accompanied by a certificate from one of the medical staff, to the effect that the case is one deserving and fit for admission. Only those are admitted who cannot be efficiently treated

at their own homes, while cases of infectious or incurable disease are excluded. In some few hospitals pay patients are admitted where there is sufficient accommodation, and it is rightly urged by Mr. Burdett in his excellent work on *Cottage Hospitals* that this system should be extended to all hospitals.

Experience has proved that in rural districts a cottage hospital of six beds will suffice for a population of 6000. The initial outlay will of course depend on whether a cottage which has already been built can be procured, and, if so, what alterations will be necessary to convert it into a hospital. If the hospital has to be built, the amount required may be estimated at £600, or about £100 per bed. In converting a cottage which has already been occupied into a hospital, the walls should be thoroughly cleaned, scraped, and afterwards replastered and washed with caustic lime. Attention must also be paid to the sanitary surroundings of the building.

The cost of furnishing a cottage hospital for six beds will amount to about £100, and the necessary surgical instruments to about £50. The maintenance per patient weekly would cost from 10s. to 15s., so that the hospital, when once started and properly furnished, will require for its support an annual income of at least £150, about £25 or £30 of which will be subscribed by patients.

Although the architectural arrangements may admit of many variations, the plan best suited for a cottage hospital of six beds should provide for a nurse's room, a three-bedded male ward, a two-bedded female ward, a single-bedded ward, which can be used as an operation room, a kitchen, which may also be used as a day-ward, a scullery, and a small mortuary. All the rooms should, if possible, be on the ground-floor, so that good roof ventilation and ample cubic space may be secured. Part of the roof should overhang, so as to form a sort of verandah

for the use of patients. It need scarcely be added that a tasteful arrangement of flowers and shrubs in the space immediately surrounding the hospital will add greatly to its cheerfulness.

As regards nursing, cooking, and management, much will depend on the size of the hospital, but efforts should always be made to secure the services of a trained nurse.

If a cesspool is used as the receptacle of excreta, it should be at a safe distance from the building, and constructed as described in the Chapter on Dwellings; but where no water is laid on, the pail or dry-earth system is to be preferred.—(See *Cottage Hospitals*, by Mr. Burdett.)

Section III.—Hospitals for Cases of Infectious Disease.

By the 131st clause of the Public Health Act, 1875, power is given to the sanitary authorities of any town or district to provide, for the use of the inhabitants, "hospitals or temporary places for the reception of the sick;" and when such provision has been made, any Justice may order the removal to the hospital of any person suffering from a dangerous infectious disease who is without proper lodging, or lodged in a room containing more than one family, or is on board ship. Judging from my own experience, however, and that of other health officers, it is very seldom that a magistrate's order is required for the removal of a patient, inasmuch as patients and their friends are, as a rule, only too glad to avail themselves of the advantages of a hospital of the kind, when proper isolation and adequate nursing cannot be procured at their own homes.

In a Memorandum issued by Dr. Buchanan in 1888, and printed in the Supplement to the Seventeenth Report

of the Local Government Board, it is recommended, as a condition of the first importance, that the accommodation for isolating cases of infectious disease shall be ready beforehand; and further, that it shall be sufficient for the treatment of different infectious diseases separately. The amount of accommodation required will of course vary for different places. As regards villages, for example, it is recommended that "large villages and groups of adjacent villages will commonly require the same sort of provision as towns. Where good roads and proper arrangements for the conveyance of the sick have been provided, the best arrangement for village populations is by a small building accessible from several villages; otherwise the requisite accommodation for (say) four cases of infectious disease in a village may be got in a suitable four-room or six-room cottage at the disposal of the Sanitary Authority; or by arrangement made beforehand with some trustworthy cottage-holders, not having children, that they should receive and nurse, on occasion, patients requiring such accommodation.

"*In towns,* hospital accommodation for infectious diseases is wanted more constantly, as well as in larger amount than in villages; and in towns there is greater probability that room will be wanted at the same time for two or more infectious diseases which have to be treated separately. The permanent provision to be made in a town should consist of not less than four rooms in two separate pairs; each pair to receive the sufferers from one infectious disease, men and women of course separately. The number of cases for which permanent provision should be made must depend upon various considerations, among which the size and the growth of the town, the lodgment and habits of its population, and the traffic of the town with other places, are the most important. There is no fixed standard,

therefore, by which the standing hospital requirements proper for a town can be measured. Furthermore, it is to be remembered that occasions will arise (as where infection is brought into several parts of a town at one time) when isolation provision, in excess of that commonly sufficient for the town, will become needful.

"For a town, the hospital provision ought to consist of wards in one or more permanent buildings, with space enough for the erection of other wards, temporary or permanent. Considerations of ultimate economy make it wise to have permanent buildings sufficient for somewhat more than the average necessities of the place, so that recourse to temporary extensions may less often be necessary. And in any case it is well to make the administrative offices somewhat in excess of the wants of the permanent wards; because thus, at little additional first cost, they will be ready to serve, when occasion comes, for the wants of temporary extensions."

Practically, however, it is found that Sanitary Authorities are generally so averse to providing any accommodation of the kind, unless under the stern pressure of an epidemic, that in rural districts, especially, the health officer may consider himself fortunate if he succeeds in obtaining a place sufficiently central to meet the requirements of a whole union, or at least the most populous parts of it. With a good ambulance, patients, if fit to be moved at all, can, I believe, be moved a distance of about eight to ten miles without risk. In reference to this point, Dr. Thorne, in his exhaustive report on Infectious Hospitals, says: "It is not that removal for a distance of some five, and even in isolated instances eight and ten, miles in a well-constructed ambulance, and over ordinarily good roads, has appeared to do harm to the particular patient, provided the removal has been effected at an early stage of the

disease. By far the greatest difficulty in the matter of distance has been found, as a rule, to lie with the relatives and friends of the patients, who assent much more readily to removal to hospital if it be within such distance as to enable them, without much trouble and without material interference with their business and other avocations, to make frequent inquiry as to the patient's welfare. In rural districts, the question of distance is usually less thought of than in urban districts, especially when the hospital to which removal is effected is in or near some centre to which the population often travel in connection with their daily or occasional pursuits."—(See *Tenth Annual Report of the Local Government Board*, 1882.)

The question here arises, and it is a somewhat difficult one to answer, What should be the ratio of beds to the population for whose wants the hospital is to be provided? Dr. Buchanan, in a very able address delivered in 1876 to the Medical Society of London, lays down the ratio of one bed to every 1000 inhabitants, and no doubt, taking this as an average estimate, it may be considered as fairly accurate. But much will depend upon the special circumstances of the district and population. For example, a poor crowded district will require a larger amount of accommodation than a district not crowded, and whose inhabitants are on the whole well off. In the latter case, the ratio of one bed to every 1500 or 2000 inhabitants, with means for temporary extension, if it should be required, might be considered sufficient.

It need hardly be said that the greatest difficulty is frequently experienced in obtaining a site. Vested interests at once take alarm because the popular prejudice against living in the vicinity of such hospitals is so great that property will, for the time being, depreciate in value. The site, therefore, which may be ultimately fixed upon may not be free from objection, but it should always be

such that no sanitary objection can be raised against it. If the soil is stiff and clayey, special care ought to be taken, by means of drainage, a free use of concrete or asphalt, and abundant ventilation, to secure perfect dryness of the building. The building itself should be sufficiently central as regards the distribution of the population of the district, sufficiently accessible from all parts of the district, and, if possible, well isolated. In rural or suburban districts, there ought to be no difficulty in obtaining an abundant supply of good water, nor any difficulty in getting rid of the excremental matters and slops.

The question of cost of site will of course vary immensely according to the circumstances of the district, while the amount of space required will also vary considerably. But, speaking roughly, no site, to afford sufficient isolation, should be less than one acre in extent, and a hospital, say of thirty beds, would require about three acres. Then, too, the site should be surrounded by a suitable fence to cut off all communication except through the lodge entrance, and such fence Dr. Thorne recommends should be a wall about 6 feet 6 inches high. It is also insisted on by the Local Government Board that the building should be at a distance of at least 40 feet from the nearest boundary or fence. The following table from Dr. Thorne's report gives important particulars with regard to the best arranged permanent hospitals which he visited:—

District.	Estimated Population.	Number of Beds.	Present Bed-rate per 1000 of Population.	Floor-space per Bed, in Square Feet.	Ward capacity per Bed, in Cubic Feet.	Cost of Hospital, excluding Cost of Site.	Cost per Bed, excluding Cost of Site.
Berkhampstead, rural . .	11,000	8	0·7	144	2000	£ 2,162	£ 270
Cheltenham, urban . .	44,000	32	0·7	Varies; mean is 144	Varies; mean is 2300	11,121	347
Darlington, urban . .	35,000	44	1·3	144 to 175	2000	10,123	225
Folkstone, urban	18,700	14	0·7	140	2000	2,800	200
Lewes, combined districts .	11,200	12	1·1	144	2000	1,975	164
Middlesborough, urban . .	56,000	32	0·6	122 to 180	1620 to 2100	6,829	213
Sheffield, urban	285,000	64	0·2	138	1810	19,785	309
Solihull, rural .	20,000	12	0·6	144 to 156	2000 to 2184	2,892	241
Tonbridge, urban . .	10,000	12	1·2	140	2000	1,394	116
Warrington, urban . .	42,000	28	0·7	144 to 175	2058 to 2529	6,555	234
Weymouth, port	?	26	?	144 to 169	2014 to 2028	5,135	192

The new Joint Hospital recently built for Warwick, Leamington, Kenilworth, and the Warwick rural district, and designed by Mr. Keith Young in accordance with the plans of the Local Government Board, cost £400 per bed.

Permanent hospitals should be built of brick or stone, and not of wood or corrugated iron, because, apart from other reasons, it was found in the course of Dr. Thorne's inquiry that it was very difficult to maintain in the latter class of buildings a sufficiently warm temperature in cold

weather. They should be built on the pavilion system, and consist of an administrative block; at least four wards, in two separate pairs, in which patients of both sexes, suffering from two different infectious fevers, can be treated simultaneously; and certain outbuildings, such as mortuary, laundry, disinfecting chamber, etc.

The administrative block is usually built in excess of the requirements of the permanent pavilions, so as to be commodious enough for any future extensions, should they become necessary; and where it is desirable to economise space, it may be a two-storied building. It should not communicate with the pavilions except by means of covered passages with free cross-ventilation; and, indeed, the Local Government Board recommend that even these covered ways should be dispensed with.

The pavilions themselves are generally one-storied buildings, but where a site is necessarily limited Dr. Thorne saw no reason to object to two-storied pavilions, provided of course that only patients suffering from one kind of infectious disease are treated in the same pavilion—the patients of one sex on one floor, and the patients of the other sex on the other floor. The distance between the several pavilions and between them and the administrative block should be equal to one and a half times their height, and when the buildings are of unequal height, it should at least be equal to the full height of the higher of the adjacent buildings. It is also recommended that in the case of a smallpox pavilion, the separation between it and the other hospital buildings should, if possible, be even still more complete, or it should be, as at Folkstone, an entirely separate institution. At Folkstone, too, arrangements have been made for the reception of better class patients into a separate block of small wards; and there is no doubt that such an addition to most infectious hospitals would be a great boon to paying patients, besides affording

means for isolating noisy or delirious patients, and doubtful cases.

Plans illustrating the sanitary requirements of small hospitals for infectious disease are arranged on three sheets accompanying the memorandum of the Local Government Board. On the first sheet is the plan of a small building to hold two patients of each sex. On the second sheet, a plan and a section of a rather larger hospital building are shown, providing for six patients, with separation of sex, and also of one infectious disease from another. The third sheet shows (Fig. 26) a small pavilion adapted to receive six male and six female patients suffering under one kind of infectious disease. On the same sheet is placed a plan (Fig. 27) of a ward block for ten patients, of similar design to plan on second sheet, and a convenient disposition of buildings upon site is also indicated.

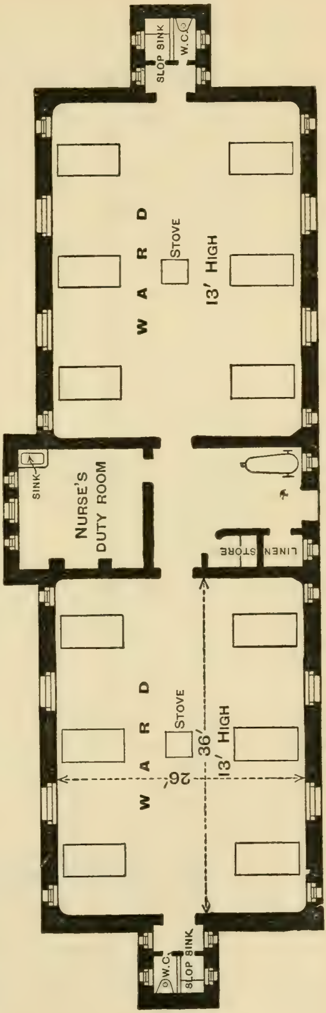
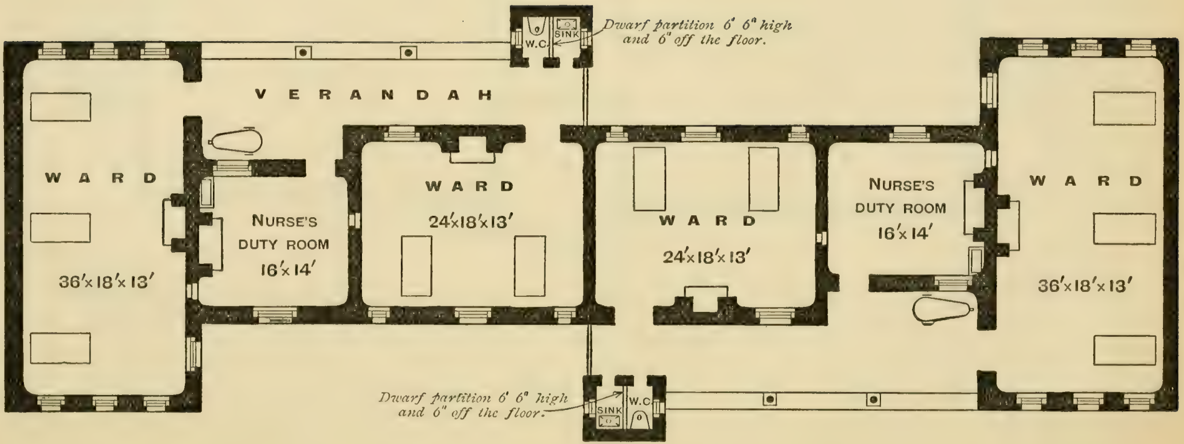


Fig. 26.

The cubic space per bed, according to the memorandum



Dwarf partition 6' 6" high and 6" off the floor.
W.C.
SINK
VERANDAH
WARD
36'x18'x13'
NURSE'S DUTY ROOM
16'x14'
WARD
24'x18'x13'
WARD
24'x18'x13'
NURSE'S DUTY ROOM
16'x14'
WARD
36'x18'x13'
Dwarf partition 6' 6" high and 6" off the floor.
SINK
W.C.

Fig. 27.

of the Local Government Board, should be at least 2000 feet, the minimum floor space per bed 144 square feet, and the linear wall space 12 feet per bed. The height of the wards should be 13 feet, and no additional height should be taken into account in reckoning the cubic space. The floors should be closely jointed, the walls either covered with Parian cement, or made smooth and lime-washed and coloured, and flat ceilings without cornices should be preferred to pitched roofs. The windows should be double-sashed, combined with fall-in or hopper windows above, and be evenly distributed in the opposite walls, so as to ensure efficient cross-ventilation. The best arrangement is found to be that which provides for one window between each bed, and one near the angles of the ward beyond each end bed. They should reach from about 3 feet above the floor level to within 6 inches of the ceiling or wall-plate, and the amount of window space should be in the proportion of 1 square foot to about 70 cubic feet of ward space—too much window space having been found to interfere with the equable warmth of the contained air.

In addition to the window ventilation, there should be ventilating openings under each bed, and just above the floor level, and each capable of being closed by means of a small sliding door on one or other side of the ward, according as the direction of the prevailing wind may determine. The ward ventilation should be supplemented by special flues opening near the ceiling, and carried alongside the chimney flues.

With regard to warming, it is found that open fire-places are best adapted for ward purposes, and preferably those of the ventilating kind. When wards exceed 30 feet in length, ventilating stoves, having an open fire-place both back and front, should be provided in the centre of the ward, and these may be supplemented by hot water pipes running round the ward.

In connection with each ward pavilion there should be an entrance lobby, a nurse's room fitted with fixed windows to command a view of either ward, a room in which to store food, and a linen store. In small hospitals the nurse's room is often fitted as a ward kitchen, and provided with a scullery sink. At the opposite end of the ward, closets, sinks, and bathing accommodation should be provided in a building projecting from the main pavilion, as already described in Section I., and separated by a lobby provided with efficient means of cross-ventilation. When no separate bath-room is provided, a movable bath on wheels is found to answer the requirements of small hospitals, as indicated in Fig. 27.

It need hardly be said that the drainage should be perfect in all its details, and the water-supply abundant and wholesome. Where there are no public sewers the closets should be dry closets, provided with movable receptacles, which can be removed through a small doorway in the outside wall, and the best way of treating the slops is by sub-irrigation from a Field's syphon flush-tank. (See Chapter XI.)

The furniture of the wards should be simple and neat; and, for obvious reasons, all bed-curtains, carpeting, or matting should be prohibited. The best kind of bedsteads are iron bedsteads, provided with wire woven mattresses, and thin horse-hair beds, which can be easily disinfected in a disinfecting chamber.

The outbuildings should consist of a porter's lodge, if the hospital is of considerable size, a mortuary, a laundry, an ambulance shed, and a disinfecting chamber, and, if necessary, a post-mortem room—all of which should be built at a safe distance from the pavilions.

Among the newer hospitals built on the best plans may be mentioned the Warwick Joint Hospital with 22 beds, the Newcastle Hospital with 105 beds, the

Nottingham Hospital with 140 beds, and the Hull Sanatorium with 150 beds.

The management of a small infectious hospital would be very much like that already described as suitable for a cottage hospital. A medical officer should be appointed who would have full powers as superintendent, but any patient should have the option of being placed under the care of his own medical attendant should he desire it, provided he pays for the cost of attendance. No obstacles ought to be thrown in the way of admitting patients, and no payment should be insisted on except in special cases or where private wards are provided. A skilled nurse can always be obtained on the shortest notice from any of the excellent nursing institutions advertised in the medical papers. At times when the hospital is not occupied, the building and bedding should be kept clean and well aired. Strict rules of management should be drawn up.

An indispensable adjunct to a hospital is a well-constructed ambulance, and here it may be mentioned that the carriage designed by Mr. Furley of the St. John's Ambulance Association has been specially commended. The stretcher should be made of wire or wicker work, and the handles should be jointed, so that when the stretcher is placed in the ambulance the handles will not encumber any of the space. Instead of a stretcher, a net hammock slung on hooks will be found to be a very comfortable mode of conveying children and young persons; indeed, for that matter, there ought to be no difficulty in slinging the stretcher itself by means of strong indiarubber bands attached to properly fixed hooks or bars. Such an arrangement would remove much of the discomfort arising from jolting, which good springs do not always prevent, and it would cost little, either in ingenuity or as regards expense, to carry it out. In

addition to the stretcher or hammock, there should be a hinged seat near the door for the attendant, and one or two hot water cans to secure sufficient warmth in cold weather and during a long drive. After being used, the ambulance should be thoroughly disinfected. The comfort of the patient would be greatly increased if, in addition to good springs, the ambulance were provided with noiseless wheels having indiarubber tires.

When an infectious hospital, or temporary extension of an existing hospital, is required at very short notice, it may be run up of wood or of corrugated iron and wood, such as the huts designed by Humphreys and Co. of Knightsbridge, London. Double canvas tents pitched on wooden floors have also been utilised to meet an emergency at Grantham, Newark, Wednesbury, and other localities, and with a large amount of success. If a number of tents are used, they are most conveniently warmed by hot-water pipes; but isolated tents, such as those supplied by Edgington and Co., London Bridge, and other manufacturers, can be warmed by stoves. Patent portable hospitals on the Doecker system are also found to answer very well, but none of these substitutes should be regarded as meeting the permanent requirements of any locality.

At seaport towns it is proposed to use hospital-ships of the "Dreadnought" type, but any old vessel with a sound hull, and large enough, would suffice. Wooden huts erected on the upper deck would supply the ward accommodation, while the body of the vessel could be utilised for the administrative department. Such hospital-ships have been used on the Thames for the reception of smallpox cases, but should only be regarded as adjuncts, and not as substitutes, for permanent hospitals on shore.

CHAPTER XV

COMMUNICABLE DISEASES: THEIR MODE OF PROPAGATION

THE rapid strides which bacteriology has made during the last few years has not only threatened to revolutionise the older theories concerning the causation and mode of propagation of communicable diseases, but has rendered any attempt at scientific classification extremely difficult. The term *zymotic*, however, is still so far in harmony with modern views, that it is retained by the Registrar-General to designate those diseases which in their course present more or less resemblance to the process of fermentation, and on account of their communicability or infectious nature, are of the highest hygienic concern. The term *specific*, again, though it embraces a large proportion of these diseases, is more limited in its application, because it assumes that the origin, *de novo*, of a contagium is as impossible as the spontaneous generation of plants or animals.

Both terms are based on "the germ theory of disease," which, in the light of recent researches, may now be said to have reached the stage of positive demonstration. Broadly stated, this theory affirms that certain diseases are invariably associated with the growth and multiplication in the system of corresponding specific micro-organisms, and that these micro-organisms are the actual contagia or causes of the disease. In fact, the germ theory has become

merged in the more precise doctrine of the microbial or micro-parasitic origin of many of the communicable diseases.

In respect to a few diseases the proof is regarded as complete, inasmuch as the conditions, first categorically stated by Koch, are capable of experimental demonstration. These are—

(1.) That the specific micro-organism must be found in the blood or tissues of the man or animal suffering or dead from the disease.

(2.) That this micro-organism can be isolated and cultivated in artificial media for any required number of successive generations.

(3.) That a pure cultivation thus obtained must, when inoculated into a susceptible animal, reproduce the same disease.

(4.) That in the blood or tissues of the inoculated animal the specific micro-organism must again be found, and be distributed as in animals infected in the ordinary way.

As the third condition is, as a rule, inapplicable to human beings, the complete proof is practically limited to diseases which attack the lower animals, but the list of such diseases, which are regarded as microbial in their origin and propagation, is now very considerable, and they include fowl-cholera, swine-fever, foot-and-mouth disease, pyæmia, and various septic diseases. The chain of evidence is also regarded as practically complete in respect to certain diseases which are common to man and the lower animals, namely, anthrax, tuberculosis, erysipelas, glanders, actinomycosis, diphtheria, and probably scarlatina. In respect to several other diseases, however, all that can be asserted so far is this,—that though a characteristic micro-organism is constantly found in the blood and tissues of persons suffering from these diseases, its causative relation can only be assumed. For instance, a characteristic microbe has been found associated with enteric fever,

cholera, relapsing fever, pneumonia, leprosy, malaria, etc., but it cannot be affirmed conclusively that the particular microbe which is regarded as characteristic of each of these diseases is the actual *contagium vivum*. Then, again, there are other diseases which prevail in devastating epidemics, such as measles, whooping-cough, small-pox, typhus fever, and influenza, in which no characteristic microbe has been isolated with certainty, and it is only by analogy that their microbial origin is assumed.

So far, therefore, the microbial origin of many of the most important of the so-called infectious diseases is open to question, and indeed there are many who maintain that even in respect to those diseases common to man and animals, in which the proof is regarded as more or less complete, the symptoms and pathological manifestations of the disease which is induced by the inoculation of cultivated virus, exhibit wide divergencies from those observed in the natural disease, although the presence of the so-called specific virus cannot be disputed. Others, again, maintain that infection is in reality due to a non-organised chemical ferment, resembling diastase, and that the microbes themselves can only be regarded as collateral phenomena which, though they may be accepted as characteristic, cannot be termed causative. Equally conflicting are the views which have been advanced concerning the precise relation which exists between the infective material, whatever its nature, and the phenomena of disease which it induces. Some hold that the enormous multiplication of microbes in the system act mainly by depriving the red corpuscles of their oxygen, while others maintain that they secrete a ferment or *enzyme*, which in its turn diffuses and acts as a poison. These poisons are variously described as *toxines* or *albumoses*, when produced by pathogenic microbes; as *ptomaines*, when formed by the decomposition of albumen by putrefactive microbes

in the dead body; and as *leucomaines*, when formed in the healthy living body in the course of functional activity.

These results of bacteriological research, however, though of extreme interest in themselves, are of little practical value in explaining the phenomena exhibited by the various diseases which are believed to be of microbial origin. They fail to explain the varying period of incubation, the distinctive features which manifest themselves in the stage of advance or eruption, or why the disease should end sometimes in recovery, or sometimes in death. The theory of *micro-strife*, as Wynter Blyth has so aptly called it, merely assumes that so soon as a colony of pathogenic microbes obtain an entrance into the body, a war commences between the leucocytes, or white corpuscles of the blood, and the invading micro-organisms. These leucocytes or *phagocytes*, according to the observations of Metschincoff, may actually absorb and so destroy the microbes; or they may be destroyed by what Hankin has called the *defensive proteids*, which are found in blood serum. In either case, if the microbes are killed, no disturbance of health is produced, but if not destroyed they multiply enormously, and secrete *toxines* or *albumoses*, which after a certain time, corresponding to the incubation period, give rise to the phenomena observable in febrile or systemic disturbance. In some diseases the microbic infection may be general, the microbe being found in the blood and various organs, such as the liver, lungs, spleen, and kidneys. In other diseases, however, the microbic invasion is localised, and the poison thus locally developed is carried by the circulation to every part of the system in the same way as when an alkaloid in solution is injected subcutaneously. (See Wynter Blyth's *Manual of Public Health.*)

Metschincoff's theory of microbic destruction, and Hankin's theory of defensive proteids, have both been advanced to explain what is understood as *insusceptibility*

or *immunity* from communicable disease. Such immunity may be either natural or acquired. In the former case, according to Hankin, it depends upon the presence of defensive proteids in the normal animal state; in the latter, upon proteids which are only found after an animal has been made immune by inoculation. The experiments of Pasteur in respect to anthrax, fowl-cholera, and rabies, first demonstrated how immunity could be conferred by inoculation with attenuated virus. But Roux, of the Pasteur Institute, has further shown that immunity can also be conferred by inoculating with the products of a specific microbe, or even with certain inorganic chemical substances; while Behring, Hankin, and others have conferred immunity on other animals by using the blood serum of animals which are known to be insusceptible to certain diseases. Further, in respect to anthrax, Hankin discovered that it was necessary to allow a certain interval to elapse between the inoculation with the albumose or protective proteid and the injection of the virulent anthrax organism to confer immunity, from which it would appear that a certain time is required for the tissues of the body to become acclimatised, so to speak, to the action of the specific infecting material, so that when the stronger poison is introduced, the resistant cells are more ready and able to cope with it. Another very interesting fact in this connection, as pointed out by Hueppe and Wood, is this, that a certain putrefactive organism, the *earth bacillus*, which in all morphological characters resembles the *anthrax bacillus*, but which does not give rise to serious symptoms even in mice, was capable, when inoculated into mice and rabbits, to afford complete protection against anthrax, which otherwise would have proved fatal to these animals. They, therefore, came to the conclusion that the saprophytic organism must be

closely allied to the *bacillus anthracis*, and that it secreted much smaller quantities of the same specific poison as the disease organism, but quite sufficient to render an animal immune. (See Discussion, Congress of Hygiene, 1891.)

According to these views, immunity produced by the attack of a specific disease must be regarded as an acquired tolerance or adaptation of the cells of the body to the specific poison of the special microbe of that disease, and the process of recovery is really the development of such immunity, which in some diseases continues throughout life.

It would appear, however, that immunity from specific diseases is often acquired quite apart from protection conferred by a previous attack. In some maladies, such as scarlatina, whooping-cough, and measles, increasing age in itself confers diminished susceptibility. Then it is well known that persons living under insanitary conditions become more or less insusceptible to manifestations of disease which frequently declare themselves to those newly exposed to these conditions. This is often notoriously exemplified in respect to new tenants or visitors taking up their residence in houses whose sanitation is faulty. Residents in insanitary houses, as well as in countries where certain diseases prevail, become, as it were, acclimatised to the inimical influences surrounding them, and their immunity would appear to be analogous to that conferred by protective inoculation by the "minimal" method. This has been established as regards anthrax, rabies, and other diseases, and is in harmony with what we know of vaccination, while to many bacteriologists these researches have suggested vast possibilities of cure as well as protection.

Referring now briefly to microbes generally, they may all be classed under the term *Bacteria*. These extremely minute organisms belong to the lowest forms of the vegetable kingdom, and are closely allied to the

Algæ. They are also known as *Fission-fungi* or *Schizomycetes,* because they multiply by a process of division, or by the formation of spores. Each single micro-organism consists of a small speck of protoplasm or vegetable albumen, which is differentiated into well-defined forms.

The round or oval cells are known as *micrococci,* and rarely exceed $\frac{1}{20,000}$ of an inch in diameter. When they occur in pairs, they are named *diplococci*; in chains, *streptococci*; in groups of four, or multiples of these, *sarcinæ*; and in irregular masses, *zooglœa.* Micrococci exhibit the Brownian movement, but are without cilia. They occur constantly in septic processes, such as acute suppuration and erysipelas.

Other bacteria of oval or cylindrical form, and with rounded ends, possess a cilium at one or both ends, and move rapidly in the presence of oxygen. When they are rod-shaped, with square-cut ends, they are termed *bacilli.* Some of these are provided with cilia, others are motionless. They elongate to form rods of various lengths, or divide transversely into separate short rods, or into chains of rods. Under certain favourable conditions they also form spores, which at first appear as round glistening specks in the substance of the bacillus, and grow at the expense of the protoplasm until the sheath bursts and liberates them, after which degeneration of the protoplasm invariably follows. These spores are extremely resistant to heat and cold, and may preserve their vitality for long periods, but in suitable media they germinate readily, a projection appearing at a point, and developing into a bacillus. Bacilli are supposed to be pathogenic in anthrax, tuberculosis, glanders, and leprosy, and are believed to be so in enteric fever, diphtheria, Asiatic cholera, malaria, and food infections. (See Fig. 28.)

Amongst other well-known forms of bacteria are *vibriones,* which are long, wavy, and ciliated. *Spirilla*

are mobile spiral filaments, which, like bacilli, often multiply by sporulation. One form, the *spirillum Obermeyeri,* was discovered by Obermeyer in the blood of patients suffering from relapsing fever, and has also been seen by many other observers.

Many of these minute organisms are endowed with great powers of movement and locomotion, but the chief factor in their rapid diffusion is their extreme prolificness.

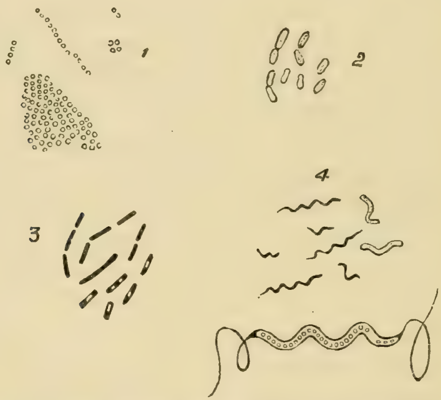


Fig. 28. (From *Practice of Medicine,* by Prof. Charteris, M.D.)
1. Micrococci. 2. Bacteria. 3. Bacilli. 4. Spirilla.

If they are placed in suitable media, and can obtain sufficient food, they multiply enormously. For their cultivation both liquid and solid media are used. Among the fluid media are broths, peptones, blood-serum, sugar, Pasteur's solution, and Cohn's solution; while among the solid media may be mentioned solid egg-albumen, boiled potato, agar-agar, nutrient gelatine, and paste. Bacteria which have their habitat in living hosts, whether animal or vegetable, are termed *parasites* or *micro-parasites,* while those which live upon dead organic matter are known as *saprophytes.* Many microbes

are capable of thriving under both conditions, and, indeed, cultivation in a non-living medium, which in itself is a form of saprophytism, is essential for the complete proof of the pathogenic nature of a given microbe. (See *Bacteria and their Products*, by Sims Woodhead.)

Microbes derive oxygen either from the air, or from media containing oxygen. In the former case they are termed *ærobic*, and in the latter *anærobic*, but many may be classed as both *ærobic* and *anærobic*. Besides oxygen, microbes require nitrogen, and carbon and inorganic salts are also necessary for their development. As a rule, carbonic acid is given off, but, as already stated, they secrete special enzymes or ferments, which vary greatly according to the microbe and its medium. Many of them are quite harmless to their hosts, and the whole mucous tract, including the respiratory and alimentary passages, abound with them even in health, while microbes, undistinguishable from those which are supposed to be pathogenic of cholera and pneumonia, have been discovered in normal saliva.

It is this difficulty in distinguishing bacteria, and the relation which they bear to their products as specific morbific agents, which has given rise to the wide differences of opinion which still characterise the wordy warfare in which the microbial origin of many of the communicable diseases is involved. Indeed, the keenness of research in this direction has threatened of late years to minimise the dangers which, from the view of practical sanitation, remain still of paramount importance, namely, pollutions or infections of air, water, and food, and reckless dissemination of contagia. These contagia, whether in all cases microbic or not, are in many diseases air-borne, and enter by the respiratory tract, as in smallpox, measles, whooping-cough, and influenza; others, as illustrated in previous chapters, may enter by food or

water as well as by air, and act primarily on the intestinal tract, as in enteric fever, cholera, and dysentery; some, as in vaccinia, glanders, syphilis, and anthrax, enter only by direct inoculation; while others, again, as in pyæmia, erysipelas, and puerperal fever, infect the system through a surface-lesion.

With regard to the incidence or prevalence of communicable diseases, the term *endemic* is applied to a disease when it is more or less restricted to a particular locality, and, owing to local causes, exhibits a tendency to linger or reappear in the district. The term *epidemic*, on the other hand, refers to a disease which breaks out suddenly and spreads widely; but some diseases, such as plague, cholera, and yellow fever come under both categories. Another term, *sporadic*, is applied to diseases such as enteric fever or diphtheria, which often crop up in isolated cases, and when no connection with previously existing cases can be traced.

In describing briefly the distinctive features, etiology, and mode of propagation of the more important communicable diseases which are of chief hygienic concern, it will be convenient, without attempting any scientific classification, to discuss in order—(1) what are called the seven principal zymotic diseases; (2) other zymotic diseases, such as cholera, influenza, epidemic pneumonia, etc.; (3) certain septic diseases, such as erysipelas and pyæmia; (4) several diseases which are common to man and animals, as anthrax, tuberculosis, and glanders; (5) parasitic diseases; and (6) certain infectious skin diseases.

Group I.—The Seven Principal Zymotic Diseases.

The following table gives the chief points of comparison connected with the seven principal zymotic diseases, with the exception of diarrhœa and dysentery:—

Seven Principal Zymotic Diseases.	Period of Incubation.	Appearance of Eruption if any.	Period of Infection.
1. Smallpox . . .	12 to 14 days (Usually 12 days).	2d or 3d day on face and forehead.	3 to 7 weeks, or till every scab falls off.
Chicken-pox . .	7 to 14 days (Usually 12 days).	1st to 4th day of fever on trunk and shoulders.	4 weeks; until every scab has fallen off.
2. Measles . . .	10 to 14 days (Usually 12 days).	4th day of fever on forehead.	During premonitory symptoms, and till end of desquamation.
Rötheln . . .	7 to 15 days (Usually 14 days).	1st to 4th day of fever on face.	Same as Measles.
3. Scarlatina . . .	1 to 7 days (Usually 3 to 4 days).	2d day of fever on trunk.	End of desquamation, and complete disappearance of throat symptoms.
4. Diphtheria and Membranous Croup	2 to 10 days (Usually 2 to 3 days).	No eruption.	Until all discharges have ceased, and throat symptoms have disappeared.
5. Whooping-Cough . .	4 to 14 days (Usually 7 days).	,,	During catarrhal stage, and so long as whoop lasts.
6. Fever—			
(1) Typhus . .	1 to 14 days (Usually 12 days).	5th to 8th day of fever on back and sides.	While fever lasts.
(2) Enteric . .	1 to 28 days (Usually 12 days).	Spots on abdomen, if any, between 6th and 14th day.	Till febrile symptoms disappear and diarrhœa ceases.
(3) Relapsing . .	4 to 10 days (Usually 6 days).	No eruption.	Until relapses cease.
7. Diarrhœa and Dysentery	...	,,	...

1. *Smallpox.*—At what period smallpox was first introduced into this country history does not enlighten us, but according to authentic records it certainly existed both here and on the Continent prior to the ninth century, and there are notices of severe epidemics from the twelfth century onwards. Indeed, after the disappearance of the plague, it became the severest scourge of the country, and so late as the close of the last century the deaths from this disease alone exceeded 10 per cent of the total number of deaths. As stated in the introductory chapter, the practice of inoculation introduced into this country on the representations of Lady Mary Wortley Montagu about the year 1720, while it modified the severity of the attack, assisted rather than otherwise the spread of the disease itself, and it was not till some time after Jenner's grand discovery of vaccination in 1796 had become general throughout the country that the gradual decline in the rate of mortality began to make itself apparent. Previous to the introduction of vaccination, it spared neither age, sex, nor position in life; every fifth person attacked died, and many of those who survived were hideously disfigured or maimed for the rest of their days. There is probably no disease so infectious, and none in which the infective material can operate at so great a distance. From cases which have come under my own observation, I have reason to believe that the contagium may be wafted from house to house on opposite sides of a narrow street, and, as the inquiries into the spread of the disease in the neighbourhood of Fulham and Hampstead hospitals have shown, there are grounds for assuming that the contagium may be carried through the air and operate at considerable distances under certain atmospheric conditions. It is true that Mr. Power's views as regards aerial extension have not received general acceptance, although they have been confirmed in some

measure by Dr. Barry's report on the Sheffield epidemic in 1887-88, but at the same time they point to the advisability of locating smallpox hospitals in situations as isolated as possible; and as regards infectious hospitals, they prove the expediency of entirely separating the smallpox block from the blocks used for the reception of cases of other kinds of zymotic disease.

The period of incubation varies from twelve to fourteen days, and the fever is ushered in with shivering, headache, pain in the loins, and often vomiting. These symptoms vary according to the severity of the attack, but the central pain in the lumbar region and vomiting are especially characteristic of the disease. The shivering is followed by fever more or less acute, and in severe cases delirium may set in within twenty-four hours. On the third day a papular eruption appears on the forehead, neck, and hands, and afterwards on the trunk and legs. If these papules remain separate and distinct, the disease is designated *variola discreta* or simple smallpox; but if they are so numerous as to coalesce, the case is known as one of confluent smallpox, or *variola confluens*. In hæmorrhagic, black, or malignant smallpox, the patient may succumb before there is any distinct eruption beyond a bright red stippling of the skin, most abundant on the lower part of the abdomen and thighs, which deepens into a dusky violet hue, accompanied often with flea-bite petechiæ, and hæmorrhage from the mucous surfaces.

In the discrete form of the disease the papules become vesicles on the third day, surrounded by an inflamed area. On the fifth day the vesicles become pustular, and the pustules subsequently become depressed in the centre or umbilicated; while on the ninth or tenth day they break and form scabs which, as they shrivel and dry up, begin to fall off about the fourteenth day of the fever.

In *variola confluens*, the initial symptoms are more

intense; the vesicles run into each other, and the face becomes very much swollen. After they become pustular, large black scabs are formed, and the characteristic odour of smallpox, which can be detected even in the discrete form of the disease, becomes sickening in the extreme. The mucous membranes of the mouth, larynx, and trachea are involved, and there is huskiness of voice and difficulty in swallowing. In severe cases it takes several weeks before desquamation is complete, while in both forms of the disease it may be laid down as a safe rule that no patient should be pronounced free from infection until all the pustular crusts have fallen off, and the whole surface of the body has been well sponged with warm water and some disinfectant soap, or several warm baths have been taken. After exposure to infection, a quarantine of seventeen days, to allow of a wide margin, is sufficient.

The infection of smallpox exists throughout the whole course of the disease. The exhalations, the vesicles, pustules, and scabs are all highly infectious. Moreover, the contagium is contained in everything that leaves the body; it may be conveyed by articles of clothing, bedding, books, etc., and may remain infective for long periods. As Dr. Parsons has reported to the Local Government Board, it is undoubtedly sometimes imported in bales of rags, and has given rise to outbreaks of the disease among the workers in paper and shoddy mills. There can be no doubt, too, that it is often transmitted by dead bodies, and I have myself known an instance in which several cases cropped up twelve to fourteen days after the funeral, along the line of streets through which the dead body, which had not been properly disinfected, had been carried.

Although the stage of the disease at which the poison is first generated in the person of the sick has not been accurately determined, there can be no question that so soon as a case is diagnosed or suspected, precautionary

measures should forthwith be adopted. Unfortunately, however, it sometimes happens that isolated cases of the disease are mistaken for cases of chicken-pox or German measles, and prompt and effective measures are neglected. In my own district I have had to investigate several outbreaks in which errors in diagnosis of this description have been made, and I have also been consulted in a few cases when the disease turned out not to be smallpox, as suspected, but either chicken-pox or measles. Of course it is often very difficult to diagnose with certainty isolated cases of any one of these diseases, and hence it is very essential that not only should the character of the eruption be carefully scrutinised, but the premonitory and other symptoms, as well as the probable source of infection, should also be inquired into. Above all, the arm should be examined as regards the character of the vaccination marks, if any. In cases of modified smallpox showing good vaccination marks, the papules are often not only sparse, but soon abort and disappear; and I have seen a very characteristic outbreak of this modified form of the disease among workhouse children, in which there was no difficulty in accounting for the outbreak, or in deciding as to the nature of the disease.

In *Varicella* or chicken-pox the premonitory symptoms are slight; the papules, which generally appear first on the trunk and shoulders, become converted into vesicles on the second day, and dry up about the fourth. The vesicles are usually globular in form, translucent in appearance, have no central depression, and collapse on pricking. Smallpox vesicles, on the other hand, are flat and circular in form, always depressed in the centre, and, being multicellular in structure, do not collapse on pricking. Moreover chicken-pox is much more a disease of early childhood. Varicella occurs as an epidemic, but beyond the period of incubation and a certain superficial

resemblance, there is nothing common between the two. If, however, smallpox is prevalent in the neighbourhood, any case presenting symptoms which are assumed to be those of chicken-pox should be regarded with suspicion, and especially if the patient is an adult. Smallpox is occasionally ushered in by eruptions which simulate those of measles, scarlatina, or erysipelas; but if the disease be smallpox, the eruption will show characteristic features within twenty-four hours, or will show signs of malignity. Of eruptive diseases, purpura hæmorrhagica, acne, erythema, urticaria, and secondary syphilis have been sometimes mistaken for smallpox, but mistakes of this kind may in most cases be avoided by a careful consideration of the history of the case.

The precautionary measures to be taken so soon as a case of smallpox is diagnosed are briefly these:—The patient, if not at once removed to a hospital, should be carefully isolated, and the house quarantined as far as possible. All persons living in the same house or adjoining houses, over ten years of age, unless protected by a previous attack of smallpox, should at once be re-vaccinated, and likewise all children whose vaccination marks are not large and distinct. Any unvaccinated children, however young, should at once be vaccinated. Details concerning the hygiene of the sick-room and disinfection will be described in the following chapter.

Vaccinia and *Vaccination.*—Vaccinia or cow-pox, which is a natural, though not common, disease of the cow and horse, never occurs spontaneously in man; it is only communicable by the direct inoculation of its own specific virus. Previous to Jenner's time such inoculation was never more than a mere matter of accident, and was by no means of common occurrence. It was matter of popular tradition, however, that persons who had been accidentally vaccinated when milking cows suffering from

the disease enjoyed subsequent immunity from smallpox, and it was Jenner's great discovery that the cow-pox, once implanted in the human subject, could be continued by inoculation from person to person indefinitely, which rendered the practice of vaccination possible. Although cow-pox was formerly common, it has become rare among cattle coincidently with the reduction of smallpox due to vaccination. The seat of the eruption is the teats and udders of cows, and this limitation suggested contact with the hands of milkers as a means of inoculation.

But the question has been warmly contested as to whether vaccinia is a disease common to animals, or a modification of what in man is known as smallpox. Many leading authorities, such as Simon, Bristowe, Hutchinson, and Seaton maintain the latter view, while there are others, as Crookshank, who are strongly of opinion that cow-pox and smallpox are essentially distinct diseases. There is no doubt that it is exceedingly difficult to inoculate cows successfully with human smallpox. In a large number of experiments Ceely only succeeded twice, while Badcock only succeeded in seven per cent of his attempts. But though it has been difficult to establish experimentally the exact relation which subsists between the two, there can be no question concerning the protection which vaccinia confers against smallpox, and the similarity which certain of its features bear to those of smallpox affords presumptive evidence that the vaccine virus is an attenuated form of the varioloid virus.

In the early days, vaccination was believed to confer complete immunity against smallpox, but it has long since been admitted that such protection is only partial. After a certain number of years a vaccinated person, if exposed to a strong dose of the varioloid poison, runs considerable risk of contracting smallpox, and indeed

this has been found to apply to persons who have suffered from smallpox, for Wynter Blyth states that he has himself seen a person, pitted from a former attack, contract a second and die. (See *Manual of Public Health.*)

Although the practice of vaccination became pretty general in the early part of the century, it was not till 1838 that it was provided gratuitously by the Government, not till 1854 that it was made compulsory, and not till 1871 was it systematically enforced by paid vaccination officers. That each of these extensions of vaccination has been followed by a marked reduction in the smallpox mortality is clearly proved by the statistics which Dr. Ogle, Superintendent-Registrar, has submitted to the recently-appointed Smallpox Commission. Thus, Dr. Ogle has shown that during 1838 to 1853 the death-rate from smallpox was 408 per million, during 1854 to 1871 it averaged 223 per million, while from 1872 to 1887 the average death-rate has been still further reduced to 114 per million. Notwithstanding these figures, however, anti-vaccinators are constantly asserting that the great reduction in the smallpox mortality rate is in reality due to improved sanitation; but, as Dr. Ogle has pointed out, this assumption is controverted by other statistics, for while the death-rate during the periods in question has declined 9 per cent, that of smallpox has decreased 72 per cent; and this decrease is by no means equally shared by people at all ages, which should be the case if attributable to improved sanitation only. This is shown in the following tabular statement:—

During the first 5 years of life	the mortality	has fallen	85	per cent.
From 10 to 5 years	,,	,,	64	,,
From 10 to 15 years	,,	,,	27	,,

Over fifteen years of age the mortality from smallpox has actually increased, owing to the fact that the protection

afforded by vaccination greatly diminishes as puberty approaches.

But the most convincing proof of the value of vaccination is afforded by the statistics of the Sheffield epidemic of 1887-88, investigated by Dr. Barry, one of the medical inspectors of the Local Government Board. Special instructions were given to Dr. Barry to inquire into every influence which could possibly bear upon the incidence of smallpox in Sheffield, but no influence was discovered beyond the single dominating influence of vaccination. Briefly tabulated, the results, as stated in Dr. Buchanan's convincing summary of Dr. Barry's most exhaustive report, are as follows :—

	Per 1000 Persons of each Class stated.			
	Attack-rate.		Death-rate.	
	Vaccinated.	Unvaccinated.	Vaccinated.	Unvaccinated.
0–10 years	5	101	0·09	44
Ditto, living in invaded houses	78	869	1	381
Over 10 years	19	94	1	51
Ditto, living in invaded houses	281	686	14	371
All ages	15·5	97	0·7	48
Ditto, living in invaded houses	230	750	11	372

In this table the figures represent the rates per 1000 of the child population under ten years, of persons over ten years of age, and of persons of all ages; first, as applying to the population of the borough generally; and secondly, as applying to the enumerated population of the invaded houses. From these statistics it appears, as Dr. Buchanan has so forcibly stated the facts, that "the vaccinated children had, as compared with the unvaccinated children living in the town, a 20-fold immunity from attack by smallpox, and had a 480-fold security

against death by smallpox; that in the invaded houses the vaccinated children had, as compared with the unvaccinated, an 11-fold immunity from attack by smallpox, and a 381-fold security against death by smallpox;" and that, as regards all ages, the vaccinated among the population generally had, as compared with the unvaccinated, a 6-fold immunity against attack, and a 64-fold immunity against death. (See Dr. Barry's Report, 1889.)

The Vaccination Acts require that every child shall be vaccinated within three months of its birth unless (1) the child dies within this period; or (2) the state of health renders postponement necessary; or (3) the child is attacked by smallpox; or (4) three or more unsuccessful attempts at vaccination have been made, in which case insusceptibility is inferred. Instances of insusceptibility, however, are exceedingly rare, for out of 38,000 primary vaccinations, Dr. Cory only failed in one case, and in that one he had no opportunity of making a third attempt.

Certificates signed by a properly-qualified medical practitioner must be produced in proof of any of the exceptions enumerated, whilst a certificate of postponement must specify a period not exceeding two months, which may nevertheless be repeated by further certificates if necessary.

There is no doubt, however, that numerous cases are lost sight of by the vaccination officers owing to the frequent migration of parents from one town or sub-registration district to another, and it is notorious that, in Leicester, Keighley, and other parts of the country, the Vaccination Acts have been openly set at defiance during recent years. It need hardly be said, too, that much of the discredit which has fallen upon vaccination as affording protection against smallpox is due to the fact that the operation is often very imperfectly per-

formed. Indeed, it is a constant complaint on the part of the poor-law medical officers, who are the public vaccinators, that some of their medical brethren make it no secret that the operation, as they perform it, is so slight that it is practically painless, though quite as effectual as the method prescribed in the official instructions. Moreover, it is well known that the proportion of certified postponements of the operation are enormously in excess in private practice when compared with those deemed necessary in poor-law medical practice, although the infant population of the well-to-do and artisan classes are, as a rule, much healthier and much less exposed to debilitating causes than infants who, in the usual course, are vaccinated gratuitously.

All these influences serve to minimise, to an extent which cannot be adequately estimated, the protecting influence which would be afforded by vaccination if it were systematically and efficiently carried out amongst all classes, but it is sufficient to point out that there is always a considerable residuum of the population who still remain unvaccinated, and a far larger proportion who have been imperfectly vaccinated, while the great bulk of the population never resort to revaccination unless under the pressure of an epidemic of smallpox. For revaccination is absolutely essential to renew in all respects the immunity conferred by primary vaccination, and as an illustration of its beneficial results it may be mentioned that in Germany, where it was made compulsory after the epidemic of smallpox of 1870-74, there has been no serious outbreak since its enforcement. In this country, however, revaccination continues entirely optional, but persons over twelve years of age can be revaccinated gratuitously by the poor-law medical officers, and when there is immediate danger of smallpox the age limit is reduced to ten.

The administration of the Vaccination Acts is under the control of the Local Government Board, and is entrusted to the Poor-Law Guardians, and not to the Sanitary Authorities throughout the country. Blank forms of certificate, together with instructions, are issued by the sub-registrars to the parents whenever a birth is registered. Although vaccination may be performed, and the requisite certificate signed, by any qualified medical practitioner, the Guardians are required by law to provide for the gratuitous vaccination of all children. For this purpose public vaccinators, who are the poor-law medical officers, are appointed, and attend at convenient stations at stated times which are duly advertised. In towns the stations are opened every week, but in scattered rural districts the dates for vaccination are held at much longer intervals, because it is not possible, as a rule, to secure a sufficiently large weekly attendance to carry on arm-to-arm vaccination. Unless in cases of serious illness, which may crop up in the interval, every child must be brought for inspection a week after vaccination. As the lymph is at its best on the eight day, if a certain week-day is fixed there is every facility afforded for arm-to-arm vaccination. It need hardly be said that the most scrupulous care should always be exercised in the selection of healthy "vaccinifers," or children from whom lymph is taken, and public vaccinators have to keep registers from which every strain of lymph can be traced through successive vaccinifers.

Primary vaccination may be carried on from arm-to-arm for an indefinite and probably unlimited time, though the question has often been raised, whether in successive transmission the vaccine virus may not become too attenuated to afford the protection originally attached to it. Results, however, do not confirm this view. The lymph should always be taken on the eighth day from

healthy children, and from normal and unbroken vesicles, each of which, on the average, will supply lymph sufficient for five cases. No lymph should be collected from vesicles resulting from revaccination, nor from vesicles showing any signs of inflammatory action. Arm-to-arm vaccination undoubtedly yields the best results, and affords a guarantee to parents as regards the healthiness of the source of lymph, but the lymph may be sealed in capillary tubes or dried upon ivory points, and retains its efficacy for a considerable time. Owing to imperfect storage and insufficient care as to the quality of the lymph, the lymph examiner appointed by the Local Government Board is obliged to reject a very large amount of the stored lymph which is forwarded to him by public vaccinators, and if this is the case with men who devote special attention to vaccination, it need hardly be said that the lymph stored by private medical practitioners is often of inferior quality, and sometimes may be altogether inert.

Calf-vaccination has of late years come largely into use, partly because it was believed that arm-to-arm vaccine was losing its protective power, but mainly on account of the fears of the possible transmission of syphilis or some other malady by vaccinating from human subjects. If calf-lymph is used, the development of the vesicles in the first child is apt to be retarded, while that of the next few who have been successively vaccinated from the first child is liable to be accelerated, and it is therefore recommended that such vaccinifers should be examined on other days besides the eighth day, so as to secure the best time for taking lymph.

As regards the operation itself, the instructions of the Local Government Board enjoin that insertions should be made sufficient to produce at least four separate good-sized vesicles, or groups of vesicles, not less than $\frac{1}{2}$ inch from each other, the total area of which on the eighth day

afterwards should not be less than $\frac{1}{2}$ square inch. That the quality and character of the vaccination, in respect to the number, area, and size of the cicatrices, has a most important bearing on the degree of protection afforded, has been amply proved by the analysis of the case mortality in the Metropolitan hospitals during the epidemics of 1871 and 1881, and was previously made abundantly clear by Marson's statistics, which are as follows:—

	Case mortality per cent.
Unvaccinated	$35\frac{1}{2}$
Stated to be vaccinated, but without cicatrices	$21\frac{3}{4}$
Having one cicatrix	$7\frac{1}{2}$
Having two cicatrices	$4\frac{1}{8}$
Having three cicatrices	$1\frac{3}{4}$
Having four or more cicatrices	$\frac{3}{4}$

Primary vaccination in the human subject is followed on the third day by a papule which on the fifth or sixth day becomes vesicular. The vesicle reaches maturity on the eighth day, when it is found to be of a grayish colour, tense, elevated, and loculated, and at this stage it contains a clear viscid lymph, which exudes when the vesicle is pricked. On the ninth day inflammatory changes set in, which are often accompanied by slight constitutional symptoms. A reddish areola will now be observed to surround the vesicle, which becomes pustular. On the tenth day the vesicle begins to dry up, and about the fourteenth day forms a dark scab, which falls off during the fourth week, and leaves a scar which should remain depressed and pitted.

On revaccination, if the persons have again become fully susceptible, the local effects appear earlier than after primary vaccination, and the local and constitutional symptoms are generally more severe. As regards unprotected persons, it is very important to remember that

successful primary vaccination within three days after exposure to the infection of smallpox will prevent the development of the disease, and it is probable that the attack will either be arrested or modified by revaccination as late as the fifth or sixth day. This is rendered possible in the first instance by the shorter period of incubation of vaccinia as compared with that of smallpox, and in the second instance by the still shorter period which generally follows revaccination.

Vaccine lymph, like smallpox lymph, contains micrococci, which are often seen in chains, but no specific microbe capable of cultivation has as yet been discovered. Filtration through porcelain not only removes the micrococci, but renders the lymph inert.

The readiness of parents to attribute to vaccination every disease, and especially any cutaneous eruption from which the child may afterwards suffer, has enormously magnified the alleged dangers attaching to the operation. It is quite possible that vaccination, like teething or any other irritating cause, may hasten the evolution of a constitutional disturbance or eruption which the child was incubating at the time, but this is by no means a common occurrence. Sometimes a roseolous rash, which may be vesicular or papular, appears on the vaccinated limb and spreads to other parts of the body. Then, again, erysipelas and diphtheria have both been known to be set up at the seat of vaccination, but such an occurrence is purely accidental, and is no more attributable to vaccination than it would be if it followed any other abrasion or puncture of the skin. The remote possibility, however, of such an occurrence suggests the advisability of not selecting rooms which are used for purposes of medical relief for vaccination stations. When the vaccinal vesicle leads to ulceration, it is due to the entrance of pyogenic microbes, and is attributable to the

dirty habits of parents, uncleanliness of skin or clothing, or the insanitary conditions of the home. Sometimes erysipelas or ulceration may unfortunately be induced by inattention on the part of the operator to the most scrupulous observance of all proper precautions, such as—brightness and cleanliness of the lancet used, and careful cleansing after each separate operation; particular care not to draw any blood, and not to use the lymph of any vesicle from which blood may have been drawn; and, above all, not to abstract lymph from any vesicle round which there is an areola, because in this case there is great risk of the lymph being tainted with the common products of inflammation.

But the great danger which, as often alleged, attaches to the operation is the risk of imparting syphilis, but with ordinary precautions this should never occur, and the cases recorded have been remarkably few. Gangrenous ulceration has been noted in three cases, and was believed to be syphilitic until the cases were examined by Mr. Jonathan Hutchinson. (See *Archives of Surgery*, October 1889.) It is true that syphilis is by no means a very rare disease, but in inherited syphilis there is no chancre, no typical development, after vaccination; the disease is wholly independent of the vaccination at the time; and there are the characteristic signs of the disease itself, such as the radiating cracks around the mouth and nostrils, and the mucous patches around the arms and genital organs. In vaccination syphilis, on the other hand, according to Professor Fournier, the disease commences with local affection, chancre, and indolent bubo, while the general phenomena never appear earlier than the ninth or tenth week after vaccination. He also distinguishes between simple vaccinal ulcer and primary vaccinal chancre as follows:—In the former, the ulcer is fully developed twenty days after vaccination, is

accompanied by much inflammation, deep ulceration, marked inflamed areola, little or no glandular swelling, and often sloughing. In the latter, the chancre, though it may appear about the twentieth day, is only in its earliest development; the inflammation is slight, there is little discharge, hardly any areola, the floor of the ulcer is smooth, the parchment induration is specific and not merely inflammatory, there is hardly any areola, and the glandular swelling is constant and indolent. Further, with regard to eruptions, true vaccinal rashes may be distinguished from secondary syphilitic rashes by the following features :—The former appear between the ninth and fifteenth day after vaccination, there is no chancre, and an entire absence of syphilitic characteristics; while the latter cannot appear until nine or ten weeks after vaccination, there will be the true specific ulcer or chancre at the site of the vaccination, and the rash itself will exhibit the true specific characteristics of the disease.

2. *Measles* or *Rubeola* is more especially a disease of early childhood, and is highly infectious. The contagium may be conveyed by *fomites*, or by means of the contaminated air of the sick-room, and readily clings to surfaces. The period of incubation is from ten to twelve days, rarely a day or two more. The eruption appears on the fourth day after the febrile and catarrhal symptoms set in, and consists of a deep red-spotted rash, appearing first on the face and forehead, and afterwards on the trunk and extremities. The rash is at first slightly raised, and is distributed in crescentic groups, which extend over all parts of the surface. It persists as a general mottling after subsidence of the fever, and in severe cases may be followed by a fine desquamation. The constitutional symptoms seldom set in until eight days after exposure to infection, and generally consist of fever more or less intense, aching pains, and vomiting,

followed by some signs of coryza, cough, and sneezing. The eruption lasts three or four days, and generally fades in the same local sequence as it appeared. In very mild cases there may be slight rash without catarrh, or catarrh without eruption. In the severe type of the disease, known as black measles, there is generally hæmorrhage from the mucous surfaces, and death may occur before the rash is thrown out.

The disease usually prevails as an epidemic, and it very rarely attacks a person more than once. When it breaks out in a school or family it is sure to spread—the catarrhal stage, which is infectious throughout, being often mistaken for a cold, so that no precautionary measures are adopted. After an attack personal infection is probably over by the end of the month, although it may persist longer. How long infection may cling to articles of clothing or linger in close rooms is uncertain. The average proportion of deaths to attacks in this country is from 10 to 12 per cent, and more than one-half the total number of deaths are of children under two years of age, while 90 per cent of the deaths occur among children under five years. Owing to the catarrhal nature of the disease the fatality is increased by cold weather and on damp soils, and it has been suggested that of late years the disease itself has assumed a more virulent type. Occasionally measles, like smallpox, becomes pandemic, and diffuses itself for a brief period over large portions of the globe. Unlike scarlatina, measles often disappears entirely from a district in the interval between epidemics.

German measles, rötheln, or *rubella* is now recognised to be a distinct specific disease, and though one attack generally protects against subsequent attacks, it does not protect against an attack of rubeola or common measles. The period of incubation is longer than measles, mostly a

fortnight. It is not so infectious as measles, nor are the symptoms so severe; but, like measles, it is a disease of childhood, though adults are liable to be attacked. The sudden appearance of the rash without any marked premonitory symptoms distinguishes it from measles. There may be slight coughing and sneezing, but within a few hours or a day after attention has been aroused the rash on the face begins to make its appearance. The rash consists of discrete spots or blotches, from the size of a pin's head to that of a bean, round or oval, and of a pale rose-red colour, slightly raised above the skin, with a distinct, or at times a faded border. After appearing on the face, these spots and blotches may also be seen on the neck and thighs, but less frequently on the forearms and lower parts of the leg. The size of the spots or blotches is less than those of measles, while their form is more round and their colour paler. The eruption lasts two days, and then disappears without any desquamation. Infection persists for a month.

The precautionary measures indicated as regards common measles or German measles are isolation of the patient, careful attention to the hygiene of the sick-room, disinfection of clothing, bedding, etc., preventing children from infected households mixing with other children; and if outbreaks threaten to become severe the question will arise, especially in rural districts, whether closing of schools may not be deemed necessary.

3. *Scarlatina* or *Scarlet Fever* has been recognised in Europe for at least six centuries, and in this country upwards of two hundred years ago. It was long confounded with measles, and it is only during the last half century that it has been differentiated from diphtheria. Although it often appears sporadically, it is, for the most part, an epidemic disease, and in many districts it rises and falls with great regularity, the usual intervals between

the epidemic waves being five or six years. Of late years it has greatly diminished in degree of intensity and prevalence, due, no doubt, to improved sanitary conditions. In this country the minimum mortality is in March and April, and the maximum in October. Children under one year of age, and especially under three months, are comparatively rarely attacked, but the incidence rapidly increases, and reaches its maximum in the fifth year of age. Up to the tenth year the mortality is higher amongst males than amongst females, but after that year the excess is on the female side, owing, probably, to the risks of home-life, and their greater exposure in nursing infected children. At all ages, however, the female sex is more liable to attack. About 45 per cent of the attacks occur at ages under five years, and 40 per cent between the ages of ten and fifteen years. There is no doubt that increasing age confers increasing immunity, and hence the double gain in shielding a child from infection during the first years of life.

During the last four or five years the etiology of scarlatina has been a subject of much contention. As already pointed out in the chapter on Food (see page 85), Klein maintains that the specific microbe of the disease is a micrococcus, which he has isolated and cultivated, and which, on inoculation into calves, produces a disease which he believes to be bovine scarlatina. Edington has also found a bacillus which he regards as the true specific microbe, cultivations of which, when injected into rabbits and guinea-pigs, produced an erythematous rash, followed by desquamation. But whether scarlatina can be classed as a bovine disease or not, all authorities are agreed that it is frequently conveyed through the agency of milk, and numerous disastrous milk outbreaks have been carefully investigated and recorded. (See page 88.)

The period of incubation is usually from three to four

days; it may be only a few hours, and it may possibly extend to seven days. The longest clear interval from a single definite case has been four and a half days. The difficulty of determining the period of incubation in many cases is the fact that slight cases often escape attention, and that these are frequently the links in the chain of infection.

The invasion of scarlet fever is usually abrupt, the temperature beginning to rise at once and seldom preceded by rigors. The premonitory symptoms are slight languor, restlessness, vomiting often, and sore throat. The fever is characterised by suffusion of the eyes, flushing of the face, and difficulty in swallowing. The lymphatic glands at the angles of the jaw become enlarged and tender, and already the palate and tonsils are red and inflamed. Very often a fine flush of redness suffuses the neck and chest soon after the throat symptoms are complained of, and the eruption may thus be among the earliest signs of the disease. It generally appears by the second day, and is well marked on the third, or it may be delayed, suppressed, or recede. When well marked the eruption begins on the neck, face, and chest, and soon spreads to the trunk and limbs. It is characterised by fine red points, closely spread over a large surface, leaving no clear skin between. They are not raised above the widely-diffused flush, and momentarily disappear under pressure of the finger. The eruption reaches its fullest extension by the fourth day, and begins to fade on the fifth and sixth. Desquamation usually begins from the sixth to the ninth day, and, according to the severity of the attack, may take five to six, or even eight weeks in completion, the palms of the hands and soles of the feet being last to peel.

There are three recognised varieties of the disease, namely, *scarlatina simplex*, *scarlatina anginosa*, and

scarlatina maligna; but the shorter classification into *scarlatina mitior* and *scarlatina gravior* is preferable. In *scarlatina mitior* the symptoms may be so mild that they attract little or no notice, and it may be three, four, or five weeks before the shreddy look of hands or toes betrays the true nature of the illness. There may be sore throat with little or no rash, or well-marked rash with slight sore throat. It is these mild cases which often play such havoc in school outbreaks, especially in country districts. The first cases are often so slight that no medical attendant is called in, nor are any precautions taken, when suddenly severe cases crop up, all of them traceable to infection through school agency, and the school has to be closed.

Scarlatina gravior includes all the more serious cases, either designated as scarlatina anginosa, when the throat symptoms are the most dangerous; or scarlatina maligna, when the high fever and its consequences are marked from the first. Between these two types and the slighter forms of the disease there are all grades of severity, and the latter often proves rapidly fatal, before even the rash appears. In the former type the throat symptoms often present a diphtheritic appearance.

Although scarlet fever may attack persons of all ages, it specially attacks children between the third and fourth year; after the fifth year the chances of attack decline rapidly, and as a rule a previous attack confers permanent immunity from the disease. Taken generally the proportion of deaths to attacks is about 10 per cent.

As regards the period of infection there is no doubt that the disease is infectious so soon as throat symptoms set in, and before the eruption appears, but, according to my own experience, it is seldom that other cases break out in the same family if the first case is promptly removed to a hospital, and proper steps are taken to

disinfect the house, etc. The patient ought not to be pronounced free from infection until desquamation has entirely ceased, and the whole surface of the body has been well bathed, nor so long as there is any discharge from secondary abscesses. During the febrile stage, and when desquamation sets in, the contagium, like that of smallpox, is exceedingly powerful and volatile, so that no susceptible person can remain in the same room for any length of time, or even in the same house, unless the patient is carefully isolated, without running great risk of contracting the disease. Moreover, the contagium is contained in everything which proceeds from the patient, but more especially in the cuticular scales given off in desquamation. These scales, laden with the specific poison, are conveyed by the currents of air to every part of the room, and may settle on clothing, bedding, furniture, walls, etc. They preserve their virulence for an unknown period of time, and when disturbed are always liable to reproduce the disease. Thus, there are several instances recorded in which the fever has been contracted by sleeping in a room which weeks previously had been occupied by a scarlet fever patient; and the fact that the poison adheres to articles of clothing is proved by instances in which the disease has been propagated by the clothing of pupils returning home from school, clothing sent home from infected laundries, or clothing received from infected houses where tailoring or sempstress work is done. Further, it has long been surmised that pet animals may be the media of conveying infection in outbreaks of scarlatina, even though they themselves may not present any throat or other symptoms.

The precautionary measures which are indicated by the above remarks are obvious, although it may be admitted that it is impossible to carry them out efficiently in the crowded homes of the poorer classes. But even

in homes where no difficulty should be experienced, the necessary isolation and disinfection are too often grossly neglected, either because they are irksome, or, if the case is slight, because they are considered to be needless. With regard to special precautions, see next chapter.

4. *Diphtheria.*—This disease was not recognised under its present name in this country till about the year 1859, though there is no doubt that under various names it has prevailed in many countries from the earliest times as croup. It was first accurately investigated by M. Bretonneau about the year 1826. Although the etiology of the disease still continues to afford ample room for research, there can be little doubt that in its origin and spread it is often intimately associated with sanitary defects. It is more or less endemic in certain localities, and frequently prevails as an epidemic. Although it is not hereditary, there is no doubt that certain individuals and families evince a great susceptibility when exposed to infection, or to causes which are likely to produce the disease.

As regards age and sex, the mortality is greater among females than among males at all ages. In both sexes the mortality increases from infancy to a maximum in the fourth year of life, and declines steadily afterwards. Of the whole number of deaths attributed to diphtheria, 53 per cent occur at ages under five years, and 82 per cent under ten years.

Dr. Roux of the Pasteur Institute has recently published the results of his researches into the bacteriology of diphtheria, in which he has endeavoured to prove that the *diphtheria bacillus* develops on the surface of the mucous membrane, and in any abrasion of the skin, but does not invade the tissues. In its growth it produces a toxine, the absorption of which produces the effects on the system. Previous to Roux, Löffler had discovered a

specific bacillus in the great majority of cases of diphtheria, which after cultivation could be inoculated upon the trachea of fowls, rabbits, and pigeons, and produce false membranes, succeeded in a certain proportion of cases by paralysis in about three weeks.

The more extended researches of Klein in respect to the intimate connection of milk-supplies with outbreaks of the disease have already been summarised in Chapter II. (see pages 77-82), and there is also strong presumptive evidence that chickens, pigeons, rabbits, cats, and dogs may suffer from diphtheria and communicate it to human beings. (See Local Government Report, 1888.)

The seasonal curve of diphtheria prevalence shows a relation to cold, the maximum mortality being reached in November and December, and the minimum in summer. The disease occurs upon both high and low levels; but Thursfield, Kelly, and others have shown that it exhibits a greater average prevalence upon damp soils, and this view is confirmed by Thorne Thorne. (See *Diphtheria, its Natural History*, etc.) A special incidence of diphtheria in damp houses, and where the autumn leaves are falling, has often been noted. It is also intimately associated with other insanitary conditions, such as defects in house-drainage; but the preponderance of opinion discards any connection with polluted water. It often occurs sporadically; and outbreaks in secluded positions have been attributed by transmission of infection by wind for long distances. Although this is possible, it is highly improbable; otherwise the disease would assume much wider extensions than have been proved to exist. Up till quite recently it was far more prevalent in rural than in urban districts; but the vital statistics of the past two years show that the mortality rate has become higher among urban populations.

Diphtheria is specially characterised by the exudation

of a tough false membrane on the soft palate, tonsils, pharynx, larynx, or trachea. This membrane, which is generally of a grayish white colour, may appear on any one or all of these parts, or it may appear in the vulva, vagina, or anus, or on a wound or ulcer. In the vast majority of cases, however, it is found on the mucous surfaces of the throat or air-passages, and generally commences on the tonsils. From thence it may spread in different directions, backwards and upwards into the posterior nares, or downwards into the larynx and trachea. The submaxillary glands usually become enlarged, and owing to the extension of the disease difficulty in swallowing and breathing are common symptoms. There is generally great prostration of strength from the first, and in very severe cases the poison sometimes kills before any local symptoms are manifested.

With regard to the period of incubation there is great diversity of opinion, but there are good grounds for believing that in the great majority of cases it does not exceed a few days, probably not more than three. The invasion of the disease is generally occult and insidious. Three or four days may be passed without any characteristic signs being observable, when suddenly the disease explodes with an attack of stridulous breathing, and on examining the throat the characteristic exudation is then seen. It is often exceedingly difficult to diagnose between diphtheria, ulcerated sore throat, croup, and some types of scarlatina. Indeed in outbreaks of diphtheria cases presenting the characteristic features of all these diseases are to be met with,—slight ulcerated sore throat, large and inflamed tonsils with patches into the pharynx and croupous extension into the lungs, and skin eruptions suggestive of scarlatina.

It is always safe to regard a patchy throat accompanied by prostration and no symptoms of scarlatina, if

not diphtheritic, as certainly infectious. Moreover, these patchy or ulcerated throats are so frequently met with as harbingers of outbreaks of diphtheria that Dr. Thorne Thorne has rightly regarded them as proving his theory of "the progressive development of the property of infectiveness." (See Trans. Epidem. Society, 1875-80, and *op. cit.*)

Among the sequelæ of the disease there is generally albuminaria as in scarlatina, and paralysis of various parts, more particularly of the soft palate, which often comes on after apparently complete recovery, or during the course of the acute malady. A striking feature in this form of paralysis is the changed character of the voice and its distinct nasality, a feature which is occasionally of great value in inquiring into outbreaks of diphtheria, when early cases may have been regarded as cases of ulcerated sore throat.

When once the disease becomes developed it is eminently infectious, the contagium being given off principally from the throat and breath, although there can be little doubt that it is also conveyed by the other excretions, and may thus become disseminated through the agency of sewers or closets. According to Dr. Parsons, Local Government Inspector, the prevalence of the disease in the later months of the year may be partly accounted for by the stirring up of the sediment in sewers by the autumn rains, the poison lying dormant until thus called into activity. In a household, and among children, it is often disseminated by kissing, and, indeed, the greatest care ought always to be taken not to bend over the patient, so as to inhale the breath. Further, there can be no doubt that the infection is most portable, and may be conveyed in articles of clothing and the like, while bedding, furniture, and even the walls and floors, may retain the virus tenaciously. Of all diseases, not even excepting scarlatina, this is the one most liable to be dis-

seminated through the agency of schools, partly because the symptoms are frequently so mild as not to prevent children from attending school, but chiefly because the disease is peculiarly liable to be spread by the breath, and may be disseminated by the throat after children are sent back to school apparently well. The greatest care ought therefore to be exercised not only in keeping children from infected houses from attending school, or mixing with others, but in not allowing those children who have been attacked to return to school until all symptoms of debility and relaxed condition of throat have disappeared. The other precautions to be taken are much the same as those recommended with regard to scarlatina (see next Chapter).

Brief reference may here be made with regard to *Membranous croup.* There is considerable divergence of opinion concerning the definition or etiology of this disease, for while some writers regard croup as acute inflammation of the larynx or trachea, followed by exudation on the inflamed surfaces, the majority of writers, following the French school, regard it as diphtheria. These hold that membranous exudation is never a result of simple acute inflammation, and this, so far as causation and sanitary precautions are concerned, is no doubt the proper view to take. So-called croup with exudation should therefore be regarded as diphtheria, and this view is strongly advocated by Dr. Thorne Thorne in his recently published work on diphtheria.

5. *Whooping-cough* or *Pertussis.*—This is an infectious specific disease, characterised by a peculiar spasmodic cough, of about six or eight weeks' duration, and chiefly affecting children and young infants. Indeed three-fourths of all the deaths attributable to it occur among children under two years of age, and by far the greatest mortality occurs in the first year of life.

The period of incubation varies from four to fourteen days, the average being about a week. Usually some catarrhal or febrile symptoms, with or without cough, appear from the fourth to the seventh day after exposure. This stage lasts a week, and the whoop mostly begins about ten days after the ingress of the disease; but there is great irregularity both in the stages and in the severity of the symptoms. The cough is paroxysmal and very characteristic, the inspiration being attended by a peculiar crowing sound. Three weeks may elapse before children exposed to infection manifest the whoop, and they should therefore not be allowed to mix with others who are susceptible until this period is safely over. The disease is highly infectious, and the contagium is readily conveyed by *fomites* and by the clothes of those in attendance on the sick or who may visit them. The specific microbe has not been isolated, nor is the disease known to be inoculable. Active infection, however, is given off by patients only slightly affected, or who are only in the early stage of the disease, and continued till some time after the characteristic symptoms have disappeared. The disease is largely spread by "neighbouring" and by school agency, and, as in the case of measles, by an utter disregard of any proper precaution in the way of isolation or the like. Indeed the prevalence of these two diseases is in great measure attributable to the culpable neglect, arising from the popular belief, amounting almost to fatalism, that children must contract them some time, and that there is therefore little use in endeavouring to take any protective steps when either disease is epidemic. The consequence is that the epidemic continues to spread so long as susceptible victims are to be found in the community, and only dies out for a time when almost all these have been attacked.

6. *Fever.*—The continued fevers are generally under

stood to be typhus, enteric, and relapsing fever; or they are classified, as in the returns of the Local Government Board, as typhus fever, enteric fever, and other, or doubtful, forms of fever.

(1.) *Typhus Fever.*—This fever has prevailed since the earliest times, and has been variously known as putrid, pestilential, ship, or jail, fever. It is an infectious febrile disease, marked by a peculiar dark mulberry-looking rash, accompanied by considerable cerebral depression, and usually lasts three weeks. It is eminently a disease of the poor, and is intimately associated with destitution and over-crowding. Except in the rookeries of our large towns, it is now a disease of comparatively rare occurrence, and cases are seldom met with in rural or small urban districts. No pathogenic microbe has been discovered.

The period of incubation has not been accurately determined, but on the average it is probably about twelve days, though Murchison maintained that it may vary from a few hours to three or even four weeks. The disease is ushered in by languor, dulness of all the senses, and fever. The mottled dusky eruption, especially noticeable over the abdomen, generally makes its appearance during the latter half of the first week. During the second week the symptoms increase rapidly in intensity until the fourteenth day, when the disease appears to have attained its height. With the third week the general symptoms begin to improve, the rash quickly disappears, and by the end of the week the attack may be said to have terminated. The mortality is about 20 per cent, but varies greatly in different epidemics.

Although not so infectious as smallpox or scarlatina, the disease is undoubtedly contagious, the contagium being thrown off by the cutaneous and respiratory exhalations. But the contagium does not travel far through the air, and it appears that if a patient can be isolated in a large

well-ventilated room, there need be no difficulty in preventing the disease from spreading in the household. But as typhus is liable to break out in dirty and overcrowded localities, such isolation can only be secured by prompt removal to a hospital.

(2.) *Enteric or Typhoid Fever.*—This has been defined as a continued fever of long duration, usually attended with diarrhœa, and characterised by peculiar intestinal lesions, a scattered eruption of small rose-coloured spots, and enlargement of the spleen. As pointed out in Chapter I., it was not recognised as a special disease until about the year 1848.

During the last few years the literature of the bacteriology of typhoid fever has become voluminous, and the results are still very conflicting. Eberth, Klein, Koch, Gaffky, Rodet, and other bacteriologists, have all devoted special attention to the isolation and cultivation of what they believed to be the specific microbe of the disease, but their experimental inoculation of animals, or feeding them on typhoid stools, cannot be regarded as altogether conclusive. The preponderance of opinion, however, would appear to be that the specific microbe is a bacillus, that this bacillus forms spores, and that these spore-holding bacilli are expelled in myriads with the stools, and may be preserved for an unknown period of time. But though it is maintained that there can be no typhoid without the bacillus, there is no evidence, on the other hand, that the spore-holding bacillus must have passed through the intestine of a human being before it becomes specific. Indeed, according to Wynter Blyth, "the most reasonable theory is that the cause of typhoid is a vegetable parasite capable of having an independent existence and propagating its kind, and completing its cycle of existence quite independent of the body; probably its normal existence is that of a saprophyte. Hence its

endemic prevalence in certain parts, hence the impossibility of always tracing typhoid from one person to another, and hence the mysterious isolated outbreaks which sometimes occur." (See *Manual of Public Health.*)

But however conflicting the views as to its microbial relations, it is generally admitted that enteric fever is essentially a filth-disease alike by those who assert its specific origin, and by those who, like the late Dr. Murchison and Sir William Jenner, maintain that it may be generated independently of previous cases. As it occurs in rural and small urban districts, my own experience leads me to believe that the great majority of scattered cases, and many of the first cases of isolated outbreaks, are due to poisoning of air, drinking-water, or other ingesta with decomposing filth. Most frequently it is found that the well-water has become polluted by soakage from some drain, cesspit, or manure heap, and in some instances it would appear as if ill-defined forms of fever, such as those vaguely termed low fever, gastric fever, febricula, and the like, may be caused by decomposing organic matter not necessary fæcal. But whether the disease is produced by befouled air or polluted water, there is a constantly accumulating amount of evidence which goes to prove that neither the air nor the water need be tainted with the specific contagium of the disease derived from a previously existing case. At the same time, there is no fact more clearly established in preventive medicine than this,—that whenever or however the disease is developed, the bowel discharges possess an infective power, which, where local conditions assist, can operate with terrible force, and often at long distances from the sick. It is rarely transmitted from person to person, but in crowded dwellings there is no doubt that there is great risk of its spreading if the evacuations and soiled clothing and bedding are not carefully disinfected and strict clean-

liness attended to. In country districts it is frequently propagated by throwing the excreta into common privies or ash-pit middens, and in several towns it is generally spread through neglect to disinfect the excreta before throwing them down the closet, and thereby specifically polluting the sewer-air.

Any epidemic of enteric fever in a sewered town points to imperfect ventilation, deficient flushing, or to faulty construction of sewers or drains (see Chapter III.), or to contamination of the water-supply, as in the outbreaks described in Chapter IX., or to polluted milk, as in the outbreaks referred to in Chapter II. In villages and country districts it points to polluted wells, bad drainage, or filthy privies and cesspools, all of which may originate the disease in the first instance, as well as be the means of propagating the specific contagium when it is developed or introduced. Its relation to the air in soils and Pettenkofer's views have already been discussed in Chapter XII.

The period of incubation is not definitely known, but in the majority of cases it is probably about twelve days, though in some instances which have been recorded the disease has set in immediately after exposure to intensely foul emanations from sewers or cesspools which have been opened. But the invasion is almost always insidious, and the initial symptoms vague. The temperature affords the most conclusive evidence of the disease if it is carefully watched. It rises progressively from day to day, and is usually a degree or two higher in the evening than in the morning. The bowels at first may be confined or relaxed, but towards the close of the first week there is generally more or less tenderness in the right iliac fossa, and the abdomen becomes more or less tumid. The characteristic spots may be detected sometimes as early as the fourth or fifth day of the fever, but usually they

do not appear until a week or more has elapsed, and in a considerable proportion of cases they are absent altogether. They are pinkish in colour, about the size of a pin's head, slightly raised and pointed, disappear on pressure and reappear when the pressure is removed. They are usually few in number, distributed irregularly over the abdomen and chest, and appear in successive crops, the duration of individual spots lasting about four days. If the case is distinguished by diarrhœa, it is at this period that it becomes most troublesome. The motions have a most offensive odour, are copious, liquid, rather pale in colour, and have a "pea-soup" appearance. Later on, when ulceration of the intestines has set in, they may become bloody, but hæmorrhage only occurs in about 8 per cent of the cases. In typical cases there is enlargement of the spleen. The disease reaches its height at the end of the third week, and the tendency to recovery is usually indicated by lowering of the temperature and abatement of the other symptoms. Relapses, however, are common, and convalescence in all cases protracted.

The principal precautions to be taken have already been indicated, but special care should be taken to disinfect excreta and soiled linen.

Cases of fever, of an undefined type, are to be met with in all outbreaks of enteric fever, and as a rule the scattered cases which crop up in rural and small urban districts are cases of this description. They are undoubtedly pythogenic, and the disease may be fairly designated "filth fever." Such cases are variously returned as low fever, fever, febricula, and gastric fever, and, like enteric fever, may spread through neglect to disinfect and properly dispose of the ejecta by burying them in a hole dug in the ground, whenever possible. As already stated, these isolated cases of fever are gener-

ally found to be associated with polluted well-water or filth nuisances.

(3.) *Relapsing Fever.*—This is a continued infectious fever without any special eruption, and characterised by a tendency to relapse at intervals of from five to seven days, and generally occurring as an epidemic. It is essentially a disease engendered by famine or scarcity of food, and during recent years has become very rare in this country.

As already pointed out, a microbe, known as the *spirillum Obermeyeri,* has been discovered in the blood, which Obermeyer, its discoverer, and other observers believe to be specific, and inoculation with blood containing these spirilla has been found to reproduce the disease in monkeys. No doubt the disease is highly infectious, and though the infection readily attaches itself to fomites, it does not appear to be capable of transport through the air except for very short distances. In the majority of cases there is enlargement of the liver and spleen, but the mortality as a rule does not exceed 5 per cent.

7. *Diarrhœa and Dysentery.*—Although diarrhœa is a prominent symptom in several diseases, it frequently assumes such a wide degree of prevalence during the summer months, and among infants, that it is variously designated epidemic, choleraic, or infantile diarrhœa. While the disease proves especially fatal among infants, Dr. Tomkins of Leicester maintains that infants and young children only form a small proportion of those who are attacked, although they furnish nearly the whole of the deaths. In England and Wales the average annual death-rate is 0·8 per 1000, but under five years it reaches the high rate of 5·7 per 1000. During the ten years, 1871-80, 63 per cent of the deaths attributed to diarrhœa occurred among infants under one year of age, and 80 per cent among infants and children under two

years. It was by far the most fatal of the zymotics, and caused a mortality of 25 per 1000 births.

It cannot be said that any specific microbe of epidemic diarrhœa has been discovered, but Dr. Tomkins found a much larger number of micro-organisms in the air of infected areas than elsewhere, and Klein has discovered various bacilli and micrococci in the alvine discharges, some of which, however, could be differentiated as characteristic of the disease. Dr. Ballard, in his exhaustive report, presented to the Local Government Board in 1889, has formulated what he has called "a provisional hypothesis" as a result of his extended inquiry, which may be briefly stated as follows:—That the essential cause of diarrhœa resides ordinarily in the superficial layer of the soil, where it is intimately associated with the life-processes of some micro-organism not yet isolated; that the vital manifestations of such organism are dependent among other things on condition of season, and on the presence of dead organic matter which is its papulum; that such organism is capable of getting abroad from its ordinary habitat the earth, and having become air-borne, obtains opportunity for fastening on non-living organic material, such as food, whether inside or outside the body, which serves as nidus or papulum; and that from food, as from all the organic matter contained in certain soils, such micro-organism can manufacture a virulent chemical poison which in the human body is the material cause of epidemic diarrhœa.

As regards influence of soil and locality, Dr. Ballard points out that a high mortality occurs on loose soils, which are easily permeated by air and water, and especially when such soils are contaminated with animal organic matter, such as sites which consist largely of ground made up with town refuse, garden refuse, or in which there is much pollution by leakage from drains or cess-

pools, or from accumulations of filth. On the other hand, excessive dryness or wetness of soil is unfavourable to the development of diarrhœa. Under ordinary conditions the prime influence is increased temperature, but this influence is not a direct influence, excepting so far as it also affects infant mortality from other causes. The real influence at work is the temperature of the subsoil, and from a large number of observations extending over a series of years, Dr. Ballard gives the following summary of his results :—

"(*a*) The summer rise of diarrhœal mortality does not commence until the mean temperature recorded by the 4-foot earth-thermometer has attained somewhere about 56° F., no matter what may have been the temperature previously attained by the atmosphere or recorded by the 1-foot earth-thermometer.

"(*b*) The maximum diarrhœal mortality of the year is usually attained in the week in which the temperature recorded by the 4-foot earth-thermometer attains its mean weekly maximum.

"(*c*) The decline of the diarrhœal mortality . . . coincides with the decline of the temperature recorded by the 4-foot earth-thermometer, which temperature declines much more slowly than the atmospheric temperature or than that recorded by the 1-foot earth-thermometer.

"(*d*) The influence of the atmospheric temperature and of the temperature of the more superficial layers of the earth . . . is little if at all apparent until the temperature of the 4-foot earth-thermometer has risen as stated above; then their influence is apparent, but it is a subsidiary one."

The other influences on which Dr. Ballard dilates are the following :—

(1.) *Density of population.* Epidemic diarrhœa is entirely a disease of towns. In 1888 the diarrhœa

death-rate in the twenty-three large towns of England and Wales was 0·60 per 1000, while in small urban and rural districts it was only 0·31 per 1000.

(2.) *Density of buildings* upon area increases the tendency to diarrhœa mortality, irrespective of the density of population which usually, though not always, accompanies it.

(3.) *Want of ventilation and light,* such as in narrow courts and streets, back-to-back houses, or in dingy and over-crowded dwellings.

(4.) *Want of cleanliness, and foul air* from sewers, cesspools, filth-accumulations, and the like. Smoke and mere chemical effluvia seem to be inoperative.

(5.) *Drinking water* may cause outbreaks of diarrhœa, independently of season, but does not produce ordinary epidemics of summer diarrhœa.

(6.) *Social position* has an indirect influence, inasmuch as the poorest classes are obliged to live in the most unhealthy surroundings, and by far the greatest incidence of the disease therefore falls upon them.

(7.) *Food,* and especially milk (see Chapter II.), often undergoes putrefactive change, owing to exposure to filth-emanations, and is thus largely productive of diarrhœa, more particularly among the infantile population. The statistics collected by Dr. Hope, Assistant Medical Officer of Health for Liverpool, and forwarded to Dr. Ballard, showed that out of 463 deaths from diarrhœa among children under six months old, only 23 had been fed from the breast alone. Infants fed entirely on breast milk were remarkably exempt from diarrhœa, those partially breast fed came next, while the highest mortality was found to prevail among infants who were artificially fed, and especially when fed by the bottle.

(8.) *Maternal neglect,* whether arising from the employment of mothers away from home, or from ignorance or want of care in nursing, adds constantly to the death-roll

from infantile diarrhœa, and this was more particularly observable in the greater mortality among illegitimate children.

Isolated outbreaks of diarrhœa have already been alluded to in connection with food, air, and water (see Chapters II. III. and IX.) which arise independently of meteorological conditions, and which do not come under the category of epidemic diarrhœa. Such outbreaks are often sudden and severe, and as suddenly disappear. Any inquiry into their causation should of course be based on a list of cases, with dates of illness and death, and would embrace inquiry into circumstances of residence and locality, drainage, water-supply, any common exposure to foul effluvia, or the food eaten. But in respect to epidemic diarrhœa, the health officer will find from mortality statistics and pauper sick returns that the disease generally attacks special houses, groups of houses, or parts of a town, and the precautionary measures indicated are—the enforcement of greater cleanliness, thorough scavenging, flushing, and disinfection of sewers, and issuing leaflets with instructions as to the feeding of infants, boiling milk, storing food, and disinfection of the excreta. As in the case of enteric fever, diarrhœal discharges infest the air of sewers, and in country districts the air of privies, cesspools, and ash-pit middens. School closets, if not properly constructed and kept properly scavenged, are very liable to spread the disease.

Choleraic diarrhœa, as it is sometimes called, is characterised by the suddenness of its onset, and is often accompanied by vomiting. The stools are at first feculant, but speedily become watery and are of a yellowish brown or rice-water colour. The name is unfortunate, because cases of this description, if they prove suddenly fatal, are sometimes returned as cholera, and give rise to needless alarm.

Dysentery depends chiefly upon inflammation of the mucous membrane of the large intestine, and may be either epidemic or sporadic. The former is peculiar to tropical climates, and takes the place of epidemic diarrhœa in this country. The latter, however, is not restricted to any locality, and is generally the result of lodgment of fœcal matter in the lower bowel, which acts as a foreign body, giving rise to inflammation.

Having thus far considered in detail the seven principal zymotic diseases, as they are called, it will be convenient to discuss briefly the other communicable diseases referred to at the outset in numerical order, and without any attempt at classification.

Group II.—Cholera and other Zymotic Diseases.

1. *Cholera.*—True Asiatic cholera is a specific disease, characterised by the suddenness of its onset, by violent purging and vomiting, cramps, rice-water stools, collapse, and a tendency to run a rapidly fatal course. The average incubatory period is from twelve to twenty-four hours, and rarely exceeds one week.

The bacteriology of the disease still remains unsettled. According to Koch it is due to comma-shaped bacilli which are found in the discharges. These bacilli can be isolated and cultivated, and when inoculated into guinea-pigs proved fatal to them. After death Koch found the intestines to be filled with fluid containing numbers of the same characteristic bacilli. On the other hand, it has been asserted by Klein and others that Koch's experiments were inconclusive; that death was not induced by the "comma" bacilli, but by the other means adopted; that other bacilli may be substituted without altering the result; that "comma" bacilli, undistinguishable from Koch's, are found in the saliva of healthy

persons, and that even cultivations of Koch's bacilli may be swallowed with impunity. Others, again, maintain that whatever the poison may be, it is chemical in its nature, and may act independently of the micro-organisms which produce it, inasmuch as the symptoms bear a close resemblance to those of muscarine poisoning.

Although the disease has prevailed in India for many centuries, it was not recognised in Europe before 1829. At irregular intervals it spreads in epidemic or pandemic extension over various parts of the world, and follows the line of traffic by land or water, so that the invasion of each new country along the line of march is almost invariably traced to some point of communication with a country already attacked. In this country it has become epidemic on four occasions, viz. 1831-32, 1848-49, 1853-54, and 1865-66. Reference has already been made in Chapter IX. (see page 280) to the last two epidemics and their intimate connection with specifically polluted water, while the views of Pettenkofer have been briefly discussed in Chapter XII. (see page 370). Sir John Simon's views, which were so forcibly enunciated at the time, continue true still—"excrement-sodden earth, excrement-reeking air, excrement-tainted water, these are for us the causes of cholera;" and whatever its microbial relations may be, these causes may be accepted as summarising the etiology of the disease wherever it prevails. Like enteric fever, it may be spread through the agency of milk, and Dr. Simpson, Medical Officer of Health for Calcutta, has recorded an outbreak of this description which has already been referred to. (See Chapter II. page 90.)

Since 1866, cholera, though more than once brought to our shores—as during the European epidemics of 1871-74 and 1884-87—has never succeeded in again establishing itself, and this result is no doubt due to

improved sanitation and greater security from sanitary defence generally.

The powers conferred on Port Sanitary Authorities by the Local Government Order of 1883, which is still in force, will be referred to in the concluding chapter, but the precautionary measures contained in the Official Memorandum issued in 1885 by Dr. Buchanan, the Medical Officer of the Board, may be briefly summarised here. After insisting strongly on the importance of proper sanitary administration as the best means of sanitary defence, the Memorandum points out that cholera in England is so little contagious in the ordinary sense, that if reasonable care is taken there is almost no risk that the disease will spread to any persons in close attendance on the sick; that it is characteristic of cholera that all matters which the patient discharges from the stomach or bowels are, or can become, infective; that in all probability such matters are only infective in so far as they are enabled to taint food, water, or air; that any choleraic discharges which are not previously disinfected, if thrown into any cesspool, drain, or other depository for filth, infect the excremental matters with which they mingle, and, probably, the effluvia which they give off; that this infective power of choleraic discharges attaches to whatever bedding, clothing, towels, and like things have been imbued with them, and renders these things, if not thoroughly disinfected, as capable of spreading the disease in places to which they are sent for washing or other purposes as in like circumstances the patient himself would be; that if by leakage or soakage from cesspools or drains, or through reckless casting out of slops, the slightest trace of the infective material gets access to wells or other sources of drinking water, it imparts to enormous volumes of water the power of propagating the disease; and that thus a single case of

cholera, even of slight degree and perhaps unsuspected, may, if local circumstances co-operate, exert a terribly infective power at long distances, and on considerable masses of population. The two great dangers, therefore, which have to be guarded against are pollution of sources of water-supply, whether waterworks or wells, and the danger of breathing air tainted with infected effluvia. And the preventive measures indicated are examination and protection of sources and distribution of water-supply, thorough scavenging, removal of sanitary defects in dwellings, flushing of sewers, and improved sanitation generally.

2. *Yellow Fever* is essentially a tropical disease, and its endemic areas are the West Indies and certain parts of the Mexican and West African coasts. In 1864 a few isolated cases occurred at Swansea among persons who had come into direct contact with infected vessels. It is pre-eminently a disease of towns, and singles out the most insanitary parts. It follows almost exclusively the lines of maritime traffic, and is not carried far by land. It is certain that ships become infected, and baggage and other fomites may retain the infection with much tenacity, though attendance on the sick does not appear to expose to much risk. According to Professor Parkes, it is highly probable that the infection is conveyed by vomited or fœcal matters, so that its etiological relations are closely allied to those of enteric fever and cholera.

The incubation period is stated to vary from two to fourteen days. The attack is generally sudden and severe, and sets in with high fever and persistent vomiting. The urine becomes albuminous or scanty, jaundice follows, and the patient passes into the typhoid state. The mortality is high. Freire has discovered a microbe which he believes to be specific, and inoculations with

an attenuated cultivation has been tried as a preventive, but the best preventive will no doubt continue to be careful attention to personal health.

3. *Malaria.*—Malarial diseases include several varieties of fever, such as intermittent fever or ague, and remittent fevers. All of them exhibit a tendency to periodicity in their course of symptoms. They exhibit their maximum of prevalence in tropical and sub-tropical regions, but are endemic in many marshy districts in Southern Europe, and occasionally spread as far north as the Baltic. As has already been pointed out in Chapter XII., they bear an intimate relation with character of soil, and degree of temperature and moisture. Malarious soils almost always contain vegetable matter, and in such districts heavy rainfall after long heat and drought is generally followed by outbreaks of malarial disease. Whether the malarial poison is the same in all varieties of the disease is still an open question, but most authorities agree with Klebs and Crudelli that the *bacillus malariæ* may be regarded as pathogenic, and there is strong reason to believe that it is saprophytic.

The malarial poison is readily transmitted by air, but, according to Professor Parkes, it is arrested by belts of trees or broad expanses of water, and does not rise many feet from the ground. Outbreaks of malaria have occurred on board ship, and have been attributed in some instances to foul bilge water, and in others to the fact that the water-supply was of marshy origin.

Ague was formerly very widely prevalent in this country, especially in the Fen districts and Essex, but of late years cases have become very rare owing to the general adoption of subsoil drainage.

4. *Dengue* or *Dengé* is a peculiar exanthematous disease which has prevailed epidemically in Eastern Africa, India, the West Indies, Mexico, and the Southern

States of America. It spreads mainly along the lines of traffic, and in its diffusive intensity bears a strong resemblance to epidemic influenza. It is a highly febrile disease, and is generally attended by swelling of the small articulations and a diffuse erythematous or spotty eruption, followed by desquamation.

There seems to be little reason to doubt that the disease is highly infectious, but no specific microbe has as yet been discovered.

5. *Epidemic Meningitis*, or *Cerebro-spinal Fever*, has occasionally occurred in this country, but the great bulk of outbreaks recorded have occurred in France, and for the most part these have cropped up in barracks. The attack is sudden, and is marked by shivering, pain in the head, vomiting, rigidity of the muscles of the back of the neck, and extreme hyperæsthesia. On post-mortem examination exudations of lymph or purulent deposits are found at the base of the brain and in the spinal canal.

Quite recently Dr. Bruce Lowe, one of the Inspectors of the Local Government Board, has reported on an outbreak of anomalous illnesses in certain parts of Northamptonshire which began to crop up towards the close of 1890. The leading character of the malady in one locality was, on the whole, pneumonic, the meningeal symptoms being generally subordinate; but in another locality, although pneumonic illness was common, there was a marked prominence of symptoms pointing to cerebro-spinal meningitis. Dr. Bruce Lowe suggests the suspicion that a gipsy family imported the disease, and assisted in spreading the infection elsewhere. (See Report to Local Government Board, October 1891.) It may further be noted that in the Departmental Report for 1888-89, Dr. Thorne Thorne gives a summary of recent occurrences of epidemic cerebro-spinal meningitis in the basin of the Mediterranean.

6. *Epidemic Pneumonia* has been more or less prevalent in England and various other parts of Europe during the last two centuries. Nearly all outbreaks occur in winter and spring, and, according to Hirsch, the greatest prevalence is observed at the seasons of most rapid and sudden changes of temperature. Although the disease occasionally occurs in epidemic form, in many instances the outbreaks are limited to single households or to institutions—such as schools, barracks, or prisons. Insanitary conditions, especially filth, overcrowding, and want of ventilation, act apparently as very powerful predisposing causes, in so much so that the disease is sometimes designated *filth-pneumonia.* It is also known as "croupous" or "fibrinous" pneumonia. The disease is very often limited to the upper lobes of the lungs, and is frequently accompanied by pleurisy and empyæma. Gastric symptoms, diarrhœa, and jaundice are common, and the prostration is frequently out of all proportion to the pneumonic invasion.

The incubation period appears to be short, usually about five to seven days; but during the recent outbreak of influenza, cases came under my observation in which the incubation period did not exceed three days. The onset is sudden, and usually marked by rigors and severe constitutional symptoms sometimes resembling in their intensity those of typhus fever. The mortality varies considerably, while the liability to attack and the average case mortality both increase greatly as age advances. In the well-known Middlesborough outbreak in 1888 investigated by Dr. Ballard, the case mortality was found to be 21 per cent. Out of a population of 97,000, 1633 persons were attacked, and 369 cases proved fatal. The peculiarity of the epidemic as observed in Middlesborough was its strong tendency to occur in groups of cases, with sequence of the attacks among members of the same

group as in diseases recognised to be infective. It was clearly proved that insanitary conditions favoured the extension of the disease, and a suspicion, which could not be altogether set aside, attached to contamination of food. Cases were very numerous in the workhouse, where the drainage was found to be faulty.

Klein, who carefully investigated the bacteriology of the outbreak, failed to detect either Friedländer's or Fränkel's *pneumo-coccus* in the diseased tissues, but he discovered large numbers of short bacilli which he named *bacilli pneumoniæ.* These he cultivated and inoculated into mice, and produced a disease, the chief and constant lesion of which was pneumonia, while further inoculations from such mice imparted the same disease to other mice. He also found that a large proportion of mice fed on samples of bacon purchased in the district exhibited similar symptoms. In all the infected mice, whether inoculated with the lung-juice of patients or cultivations of the bacilli, or fed on presumably infected bacon, these bacilli were found in the tissues and could be transferred to other mice. Dr. Ballard, therefore, claims for the Middlesborough epidemic pneumonia a place among the class of "acute specific fevers," and suggests by preference the name of "pneumonic fever."

Epidemics of pneumonia often occur coincidently with outbreaks of other diseases, and notably enteric fever, while in the fatal outbreak of influenza in 1891 the disease assumed enormous prominence.

7. *Epidemic Influenza.*—The name of this disease is of Italian origin, and came into use two centuries ago, but much confusion has arisen from the prevalent misapplication of the term to severe catarrhs, which are themselves generally more or less infectious. Many epidemics of true influenza have been recorded during the last two centuries, and during the present century as

many as ten—the last occurring in 1847-48. But the interval between this and the recent epidemic of 1889-90-91 was so great that the disease was practically unknown to the great bulk of medical practitioners of the present day. The recent epidemic, however, has not only developed a huge literature on the subject, but has opened up a wide field for dissension in its bacteriological relations. Bacteria in profusion have been found in the sputum and blood and lung-tissue, but none are agreed as to the characteristics of a true pathogenic microbe. This much, however, has been established by Dr. Parsons's most elaborate report, recently presented to the Local Government Board, that the disease is eminently infectious, and that though its progress and mode of extension are highly irregular, it is propagated mainly, perhaps entirely, by human intercourse. The belief that the poison of the disease may be wafted across continents, and that the atmosphere plays the principal part in its diffusion, is controverted by the fact that the progress of the 1889-90 epidemic was found to be contrary to the prevailing winds, and that it was independent of season or any particular kind of weather. Moreover, it has not been shown to have travelled faster than human beings could travel, nor has it occurred among persons placed under circumstances precluding its communication by human agency. Dr. Parsons also found "that as a general rule it has appeared in each country, first in the capital or the ports of entry, or the frontier towns in communication with countries previously invaded, and that the towns, as a rule, have been affected earlier than the country places." Further, its power of infectiveness has been pre-eminently displayed in the rapidity with which it spread in public services and establishments where large numbers were employed in enclosed places, and in institutions in which the inmates are brought much into association.

It had been noted in former outbursts of influenza that horses suffered from a similar disease at the same time as man, but in the 1889-90 epidemic Dr. Parsons has made it clear that horse-influenza, so far as it was prevalent, preceded the human disease. In both, however, he found a great similarity in the chief symptomatic features, for in both the period of incubation was short, and stated to be from two to four days; in both the invasion was sudden; in both the duration of the acute period was brief; in both there was an absence of marked catarrhal complications in the majority of cases; and in both the leading features of illness were shivering, aching pains, hard dry cough, fever, and great prostration. But though the features of the disease in the horse and in man showed this great resemblance, Dr. Parsons admits that it is possible they are distinct diseases.

The history of the recrudescence of the epidemic in 1891 has not yet been written, but when the main facts have been recorded, it will be found that epidemic influenza during 1891 has been attended with a far greater mortality in this country than any epidemic of specific disease during the last half century. The percentage of lung-complications was enormously high, and in many parts the disease was associated with epidemic pneumonia, which prevailed chiefly among adults who had reached, or had long past, middle age.

In discussing the possibilities of combating the disease by early information and isolation, Dr. Buchanan, in his prefatory remarks to Dr. Parsons's report, frankly admits the immense difficulties which stand in the way. For better means of repressing influenza, he bases expectation on a fuller knowledge of the natural history of the disease, and in this direction Dr. Parsons's report is by far the most valuable contribution which has as yet been made to the literature of the subject.

8. *Mumps*, or *Cynanche Parotidea*, is an acute infectious disease which specially attacks the parotid and submaxillary glands, and is often attended with a considerable amount of swelling and pain, as well as difficulty of opening the mouth and swallowing. The disease occurs in all parts of the world, in brief but sometimes intense epidemics, which, however, cause little or no mortality. In this country outbreaks usually occur in the winter or spring, and frequently in concurrence with epidemics of measles, and, less rarely, with scarlatina prevalence. It does not show any periodicity in its return, and may be absent from districts for years.

Nothing is definitely known of its bacteriological relations, nor of its etiology, beyond its extreme infectiousness by the breath. The period of incubation is about a fortnight, but longer intervals have been recorded. It is therefore often very difficult to repress an outbreak occurring in schools, though, as a rule, three weeks may be considered as a sufficient time for the isolation of a patient, or for the quarantine of a person who has been exposed to the disease.

Group III.—Septic Diseases.

In this group are included erysipelas, pyæmia, septicæmia, and puerperal fever.

1. *Erysipelas* is an infectious disease, the common external sign of which is an inflammation of the integument, extending in some cases to the areolar tissue, and tending to spread. A characteristic microbe associated with the disease was discovered by Fehleisen, which has stood all the tests of specificity by cultivation, inoculation, and reproduction of the disease in rabbits.

The most usual means of infection is by a wound, but numerous cases occur which used to be designated

idiopathic, in which no abrasion can be detected. The scattered cases of this description, which occur in rural districts, and all of which must now be notified where the Infectious Diseases (Notification) Act is in force, are mostly of a trivial nature, and certainly suggest that if the disease is due to a specific microbe, the so-called *streptococcus erysipelatosus* must be saprophytic. At one time erysipelas was a formidable disease in the surgical wards of hospitals, but the fact that improved sanitation has almost completely banished it proves that the disease has intimate relations with the ordinary putrefactive changes which occur in animal organic matter.

2. *Pyæmia, Suppuration, Septicæmia,* etc.—Professor Ogston of Aberdeen, Garré, Fränkel, and others, have endeavoured to differentiate these several varieties of septicism by the appearances and the behaviour of the micro-organisms which abound in all of them, but the results are by no means conclusive. The so-called *streptococcus pyogenes* resembles closely the streptococcus of erysipelas, and the micro-organism associated with puerperal fever. Carbuncle, whitlow, and osteo-myelitis have been determined by Garré to be due to *staphylococcus pyogenes aureus.* Pyæmia, again, has been divided into two kinds, presumably based on its microbial relations. In one the symptoms are believed to be due to the absorption of toxines, which may be produced by non-pathogenic organisms, and which is variously designated septic-poisoning, blood-poisoning, or sapræmia. In the other form of pyæmia there are well-defined suppurating centres, as a suppurating knee-joint or open wound, from which a continuous supply of poisoning material is kept up, and this is known as *septicæmia,* or the *micrococcus-poisoning* of Ogston. Unfortunately, however, for the strictly specific microbial origin of these septic diseases, Fränkel maintains that he has discovered the *strepto-*

coccus pyogenes in the blood without giving rise to any symptoms.

3. *Puerperal Fever.*—Although this term is often used very loosely, it is ordinarily restricted to manifestations connected with the puerperal state resembling those of pyæmia. In this fever also a microbe bearing a close resemblance to the erysipelas micro-organism has been discovered, but Winter and Döderlein have both shown that the healthy vagina and cervix uteri swarm with organisms pathogenic in appearance and behaviour, but it is only when the lochia are present that organisms were found which on cultivation and inoculation produced abscesses. There is no doubt, however, that the disease is very liable to be spread from patient to patient by medical practitioners and midwives, if the most scrupulous care is not given to clean hands and finger-nails. A midwife, after attending a case of puerperal fever, should be prohibited from attending a second case of parturition for at least three weeks, and both midwives and medical attendants should use a disinfectant solution for washing the hands, such as a corrosive sublimate solution of 1 to 1000, or of carbolic acid 5 per cent, before and after all midwifery cases. Anti-septic precautions and improved sanitation have practically banished the disease from lying-in hospitals, but unclean hands and finger nails, probably far more than insanitary surroundings, still contribute largely to the death-roll of puerperal women.

Formerly it was believed that scarlatina was intimately associated with the spread of the disease, but as cases have been more carefully investigated, such intimate relation between the two has not been confirmed.

The tangled microbiology of these septic diseases only serves to show that, given filth or filth infection, and microbes crop up in abundance; secure perfect cleanli-

ness and wholesome conditions, and they are deprived of their power for morbific mischief.

Group IV.—Diseases common to Man and Animals

In this group are included tuberculosis, anthrax, glanders, hydrophobia, tetanus, actinomycosis, and foot-and-mouth disease.

1. *Tuberculosis.*—Apart from phthisis, tuberculosis entails a heavy mortality among children in the form of "tabes mesenterica" and "tubercular meningitis," although it must be admitted that both terms are employed somewhat loosely in death-returns to ensure reliable statistical data. Phthisis, however, under its popular name of consumption, still ranks among the most fatal and widely-spread of all diseases. During the three decennial periods—1851-60, 1861-70, 1871-80—the average death-rate per 1000 of the population in England and Wales was 2·7, 2·5, and 2·1 respectively. The reduction in the death-rate exhibited by these figures is no doubt mainly attributable to improved sanitation and a higher standard of national health. For whatever views may be entertained regarding its microbial origin, it is, in large degree, a hereditary disease, and, as abundantly shown in Chapters III. and XII., its incidence is greatly influenced by overcrowding, by air-impurities in industrial employments (see page 115), and by dampness of soil and dwellings.

But the researches, more especially of Koch, have opened up new possibilities of infection, inasmuch as the special *bacillus tuberculosis*, which is found in all tubercular lesions in man, is also found in the organs and tissues of cattle whose flesh is used as food, or in the teats and udders of milk-cows, and also in cow-milk. The dangers of infection from eating tuberculous flesh or using tuber-

culous milk have already been discussed in Chapter II. (see pages 45 and 83), and it will suffice to point out here that the result of the discussion on the subject at the recent Congress of Hygiene and Demography appears to be that though the dangers of eating tuberculous meat have been exaggerated, the danger is admitted, and especially in respect to milk obtained from cows suffering from tuberculosis.

In this direction there is no doubt that bacteriological research has conferred very material advantages from a public health or preventive point of view, but the policy of prevention must still remain based on the old lines, namely, a wider recognition on the part of the public of the great danger attaching to hereditary influence; and as summed up by Dr. Ransome in the Milroy Lectures for 1890, the adoption of general preventive measures on the following lines:—

(*a*) Free ventilation for all in-door or underground workers.

(*b*) Out-of-door exercise for boys and girls, as well as men and women, and for this purpose the provision in towns of parks and recreation grounds.

(*c*) In choosing the business or profession of those boys who have shown a tendency to phthisis, it should preferably be one in which there will be little office-work, and as much out-door work as possible.

(*d*) Great care with regard to food, especially tuberculous milk.

The hopes which have been so eagerly and widely entertained that tuberculosis might be arrested or cured by inoculation have not been realised by the results of Koch's treatment, from which so much was expected, and it may be safely predicted that neither prevention nor cure lies in this direction, but will continue to rest on the old lines. At the same time it must be admitted

that Koch's researches have been of the greatest value in emphasising more forcibly than heretofore the infectious nature of phthisis, and every great advance in our knowledge of the natural history of a disease furnishes a more exact estimate of the best methods for prevention.

Leprosy is supposed to be allied to phthisis, but the microbe first discovered by Hansen in 1874 is not identical with the tubercle bacillus. Unlike the tubercle bacilli, the bacilli found in leprosy are difficult of inoculation upon lower animals, and while they swarm in the diseased tissues, they are not found in the blood, and are believed to spread by means of the lymphatics. The fact that leprosy, which was common in England during the eleventh century and for several centuries afterwards, has long been entirely extirpated from this country, shows that by isolation, and probably also by improved sanitation, it is possible to extirpate the disease in every country.

2. *Anthrax* affects cattle, horses, sheep, and goats to a considerable extent in some countries, and is associated with a specific microbe, the *bacillus anthracis*. It is transmitted to men engaged in slaughtering animals suffering from the disease, or employed in treating their hides or wool, as in *wool-sorters*' disease (see page 114). Amongst the former *malignant pustule* is developed, and in wool-sorters' disease the spores of the bacilli find entrance by the respiratory or alimentary tracts. The bacilli of anthrax are readily destroyed by heat or other disinfecting agencies, but the spores are found to be extremely resistant. Pasteur has succeeded in protecting animals by inoculating with the attenuated virus. The dangers attaching to the consumption of the flesh of animals suffering from anthrax have already been discussed in Chapter II.

3. *Glanders*, or *Farcy*.—Although this disease has been transmitted from man to man on rare occasions, the

infection is usually from the horse. It is not by any means a common disease, and the mode of infection is by inoculation of the nasal and respiratory passages. The incubation period ranges from three to eight days, and the mortality is high.

4. *Hydrophobia* is the name given to rabies occurring in the human subject, and is imparted to man by the bite of rabid dogs, or, more rarely, rabid cats, foxes, or wolves. The incubation period ranges from six weeks to two years. Statistics based on cases of bites by animals proved beyond doubt to be rabid show that the disease manifests itself in 15 per cent of the cases bitten. Bites on the face, however, and particularly by rabid wolves, are the most fatal, and are attended with a much shorter period of incubation. Although the numerical mortality is comparatively insignificant, the disease has assumed increased interest and importance from a preventive point of view on account of Pasteur's preventive method by inoculation. No specific microbe has been isolated with any certainty, but micrococci and bacilli have both been found in the spinal cord of rabid animals. Pasteur inoculates with portions of the virulent cord, which gradually loses its virulence by exposure to dry air. Inoculation is commenced with attenuated virulent material, and continued at short intervals with material of increasing virulence, until at last complete immunity or cure is believed to be attained. Although the mortality is ostensibly reduced from 15 to 1·36 per cent, there are still many whose attitude towards the efficacy of Pasteur's method is one of doubt and question.

5. *Tetanus* affects horses, which may impart it to man, although such instances are rare. Traumatic tetanus is always more or less associated with filth-inoculation of wounds, and is therefore preventable by strict attention to cleanliness and by adopting antiseptic precautions.

A characteristic microbe has been identified and cultivated, and the disease can be produced in animals by inoculating with stable refuse.

6. *Actinomycosis.*—This disease affects the jaws of cattle (see page 47), and is associated with a ray or fission-fungus. The disease is transmissible in cattle by inoculation, but is rarely communicated to man.

GROUP V.—PARASITIC DISEASES

Although the majority of the diseases discussed in the previous groups may be classed as micro-parasitic on account of their intimate relations with micro-organisms, there are certain diseased conditions due to the invasion of parasitic animal organisms, which may be fitly noticed here.

1. The *Tæniada*, or *Tape-worms.*

(1.) The *Tænia solium,* or tape-worm, infests the small intestine, and varies in length from two to ten feet or more. It consists of a small head about the size of a pin's head, a neck about an inch long and unjointed, and a long segmented body. Under the microscope the head is seen to present four prominent suctorial discs, and between them a rounded elevation or *rostellum*, which is surrounded with about twenty-six hooklets of different sizes. The neck broadens out into the body, which consists of square or oblong flat segments named *proglottides,* each of which is provided with double sexual organs. Ova are produced in the segments, and escape with the excreta if the segments rupture or become detached, or if the whole worm is expelled. These eggs are spherical in shape, have a thick brownish shell, and are about $\frac{1}{700}$ inch in diameter, and when mature they may be seen to contain embryos furnished with hooklets.

As already explained in Chapter II. (see page 49),

the ova, when swallowed by pigs, reach the intestinal tract, where the cell-cyst bursts. The embryo then escapes, and, attaching itself by its hooklets to the mucous surface, afterwards works its way into the tissues, and there becomes encysted as the *Cysticercus cellulosus* of measly pork. If the flesh containing these cysticerci is eaten by other animals in an uncooked state, the head or *scolex* reaches the alimentary canal of the new host, loses its cyst, and then develops joint after joint into the tape-worm. Man is very subject to tape-worms, and also, though much more rarely, to their cysticerci.

(2.) The *Tænia mediocanellata* is perhaps as common as the *Tænia solium*, and somewhat resembles it, but the head has no rostellum or hooklets, though it is furnished with four suctorial discs. The *Cysticercus bovis* is smaller than the *Cysticercus cellulosus*, and occurs in the flesh of cattle. It consists of a cyst, and a scolex which is identical with the head of the tænia itself.

(3.) The *Bothriocephalous latus* is the longest of all the tape-worms, and is principally met with in Sweden, Russia, and Poland. The head is ovoid or club-shaped, and provided with two longitudinal grooves or suckers, but no hooklets. The embryo is ciliated, and found in river-water, and, according to Cobbold, the cysticercus is believed to have its habitat in fish.

(4.) The *Tænia echinococcus* specially affects the dog or wolf. The head or scolex resembles that of the *Tænia solium*, but the worm itself is only about a quarter of an inch long, and has only four segments, the last of which is provided with sexual organs. The ova are spherical, and after being voided, find their way into the human body either in drinking-water, or on the leaves or stems of young vegetables. The cysticercus is a dangerous human parasite, under the name of hydatid, which affects the liver and various other parts of the body, such as the

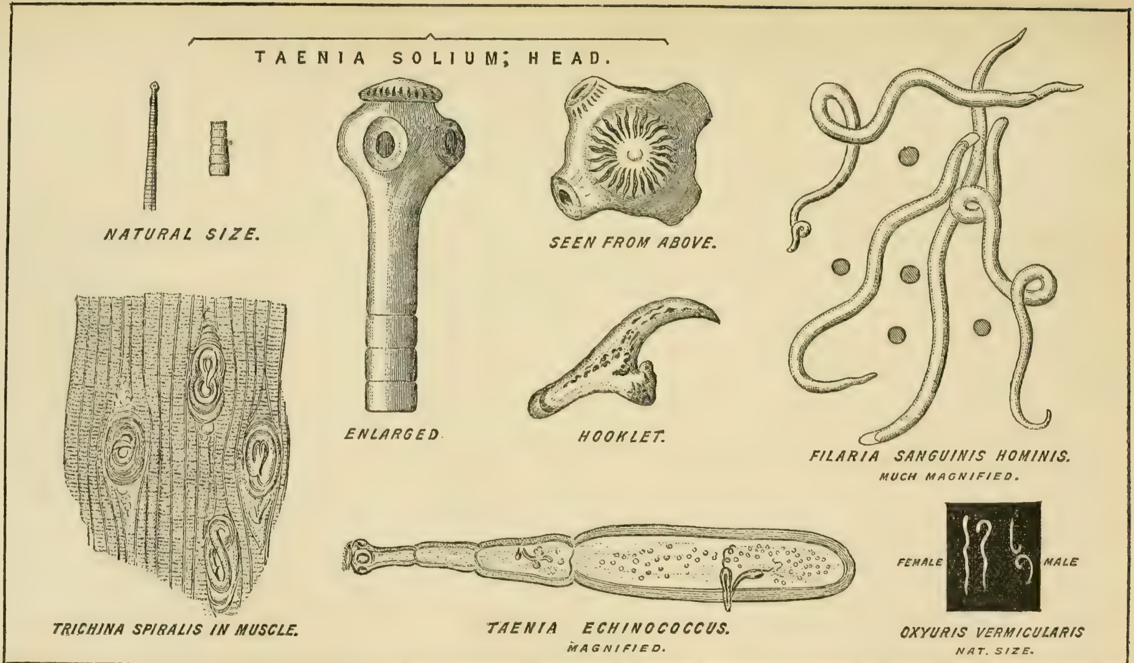


Fig. 29. (From *Practice of Medicine*, by Prof. Charteris, M.D.)

stomach, intestine, or lung. But the ova develop in other animals besides man, and especially in sheep, the echinococci of which are devoured in the offal by dogs which frequent slaughter-houses, and in them reproduce tape-worms. In Iceland, owing to the infection engendered by the huddling together of dogs and human beings in close dwellings, it is notorious that about one-seventh of the total mortality is due to hydatids.

There are other varieties of tape-worms, such as the *Tænia nana*, which is common in Egypt, Italy, and Sicily, and the *Tænia cucumerina*, but these do not require special notice.

2. *Nematoda*, or *Round-worms.*

(1.) The *Ascaris lumbricoides* infests the small intestine in man and other animals, and it appears to be common in all climates. The head consists of three conical prominences, furnished with tactile papillæ and minute teeth. The male worm is about 6 inches long, and the female about 12, and in both the body tapers from before backwards. The ova are nearly round, brownish-yellow in colour, and measure about $\frac{1}{450}$ of an inch in diameter. It is believed that the ova have their habitat in some intermediary host, and are conveyed into the human system through the agency of drinking-water.

(2.) The *Oxyuris Vermicularis*, or small thread-worm, infests the colon or rectum, and is generally met with in children who are poorly fed. The male worm is about a quarter of an inch in length, and the female about half-an-inch. The natural history of the thread-worm has not been well established, but it is probable that it is frequently disseminated by drinking-water.

(3.) The *Anchylostoma Duodenale*, or *Dochmius Duodenalis*, as it is sometimes called, is exceedingly prevalent in Egypt, and also in Germany, Switzerland, and Belgium. It produces a severe form of anæmia, especially among

brick-burners, miners, and navvies who work in tunnels. The mouth of the worm is armed with four claw-like teeth, by which it attaches itself to the villi of the small intestine, and often leads to hæmorrhage.

(4.) The *Tricocephalus dispar* is a whip-like worm, consisting of a thick, short hinder-part, and a long, spiral, filament-process, anteriorly. Its habitat is the cæcum. It is rarely seen in this country, but, according to some authorities, it produces, along with the *anchylostoma* and an insect larva, the disease known as beri-beri.

(5.) The *Trichina spiralis* produces the well-known disease *Trichinosis*, which is far less common in this country than in Germany, where ham, pork, and sausages are often eaten raw, or in an imperfectly cooked state. The inspection of trichinous meat, as well as the microscopical appearances of the trichina, have already been discussed in Chapter II. (see page 48). When trichinous food, such as pork or ham, is eaten in an uncooked state, the capsules containing the trichinæ are dissolved by the gastric juice, and the liberated trichinæ develop rapidly, the male attaining a length of $\frac{1}{18}$ of an inch in two or three days, and the female about $\frac{1}{8}$ of an inch. Ova are then formed and impregnated in the female, and are hatched in about a week. So soon as the embryos escape they burrow into the walls of the intestine, and find their way into the tissues of all parts of the body, and especially the muscular tissue, where they again become encysted within about a month after the trichinous food has been ingested.

Trichinosis is common to several rodents and other animals, as well as man and pigs. In man the symptoms commence within about a week with intestinal disturbance somewhat resembling that of typhoid fever. The tongue becomes coated, and this is generally accompanied by diarrhœa and great prostration. If fever is present,

the symptoms are usually slight, but it is characterised from the first by an abnormal amount of perspiration. The malady continues in its acute stage for about one or two weeks, and then gradually subsides, but fatal peritonitis, enteritis, or pneumonia may supervene, or in severe cases the patient may die from exhaustion. In addition to the remarkable increase of perspiration, so-called "muscular lameness" sets in when the tissues are invaded. The muscles become painful, swollen, and stiff, as in rheumatism, except that the joints are not affected, while there is œdema of the face and eyelids, which may subsequently involve the hands and feet, and also the serous cavities. Owing to implication of the larynx, the voice often becomes hoarse or aphonic. The severity of the symptoms will vary greatly according as the food was highly infested or not when ingested, and of course will also greatly depend upon the degree of cooking. The mortality is sometimes slight, but in several outbreaks it has reached 20 or 25 per cent. When recovery takes place the trichinal cysts become coated with lime salts, and the encapsuled parasite dies.

Although the disease is not very often observed in this country, there is every reason to believe that many cases are not accurately diagnosed on account of the somewhat puzzling symptoms which they exhibit.

(6.) The following animal parasites are noted indiscriminately :—

(*a*) The *Pentastoma constrictum* infests the liver and lungs. It measures half-an-inch to an inch in length, and is recognised by the presence of twenty-three rings. It is common in some parts of Africa, and sometimes attacks European residents in the West Indies.

(*b*) The *Filaria Sanguinis Hominis* is a hair-like parasite, which may attain a length of three or four inches, which, when it invades the urinary tract, produces

chyluria, and it is also associated with elephantiasis. The parasite in the immature form, as well as the ova, can be detected in the blood and urine. The ova are about $\frac{1}{1000}$ inch long, and the embryo is enclosed in a transparent tubular sac, which is extremely delicate and translucent. The parasite is found chiefly in the East and West Indies, but it has occasionally been met with among persons who have never left this country.

It has recently been shown that embryo *filariæ* in the blood are imbibed by the mosquito, which deposits its eggs in water along with the ova of the *filariæ*. It is supposed that the embryo passes its next stage of existence as a free nemotode in water, but that it can only attain its full stage of sexual development in the human body, after obtaining entrance through the skin of bathers, or very probably in drinking-water.

(*c*) The *Filariæ Medinensis*, or *Guinea-worm*, is endemic in tropical regions. The worm itself varies from one to three feet in length, and the embryos affect minute aquatic crustacea, and obtain entrance to the human body either through the skin while bathing, or by means of drinking-water.

(*d*) The *Bilharzia Hæmatobia* is a bisexual entozoon of the fluke type, the male being about half-an-inch long, and the female about three-quarters of an inch. It infests the branches of the portal system, and the minute veins of the kidney, ureter, and bladder. The symptoms vary according to the region attacked, but if the urinary system is invaded, there is generally blood in the urine, and shreds of mucus are passed which are found to contain the ova of the parasite.

It is believed to gain an entrance into the human body either by drinking water, by eating infested salads, or by direct infection of the alimentary or urinary tracts while bathing.

Group VI.—Communicable Diseases of the Skin

Certain *Parasitic and other Infectious Diseases of the Skin* often spread among school children, and may become very troublesome. Indeed, it should be made a rule among teachers that any child exhibiting an eruption on the face, head, or hands, should be prohibited from attending school until cured, and skin cleanliness should be enforced as strictly as possible at all times.

1. Ringworm (*Tinea tricophytina*) is a parasitic disease caused by a fungus. When it attacks the scalp it is known as *Tinea tonsurans*, and when it appears on the general surface of the body it is termed *Tinea circinnata*. Tinea tonsurans is rarely seen among adults, but often becomes a very troublesome complaint among school children. The disease is easily recognised by the irregular scaly patches which generally appear first on the top of the head. The hairs which grow on these parts are withered and dry, and most of them are broken irregularly. Under the microscope the fibrous structure of the hair, if first steeped in liquor potassæ, will be seen to be split up, and filled with chains of spores.

The disease is spread largely by the mixing of hats and caps at school, and there is no doubt, too, that it is often communicated by the combs and brushes used by the hairdresser.

2. *Tinea favosa*, or Honeycomb Ringworm, is also a very obstinate skin affection, due to the presence of a fungus, the *Achorion Schönleinii*. There is no doubt that the disease is infectious, and it generally attacks the scalp. It requires a congenial soil on which to spread widely, and it is therefore found most prevalent among the children of the very poor, and especially when they are dirty and ill-fed. Cleanliness and healthy surroundings banish the disease. In the early stages the patches

are irritable and scaly, after which bright yellow crusts, small and distinctly cup-shaped, are formed, and eventually these crusts fall off. Owing to the irritation of the skin, scratching gives rise to numerous secondary lesions, such as bleeding and suppuration. It is believed that the disease is sometimes spread by cats.

3. *Impetigo Contagiosa.*—This is a contagious vesiculo-pustular eruption which attacks children in the vast majority of cases, and often spreads in the same family, or in schools. The small vesicles first make their appearance on the face, and though they sometimes appear on the hands, do not often spread to other parts of the body. The contents of the vesicles, some of which may be as large as lentils, become milky, then sero-purulent, and afterwards dry up into scabs, which, on falling off, leaves a smooth surface. The eruption is composed of one or more crops, and, if neglected, may not disappear for six or seven weeks.

4. *Eczema.*—Unna's views with regard to the contagiousness of eczema have received the strongest confirmation in the prevalence of a fatal epidemic of this disease which broke out in the Paddington and Marylebone Workhouse Infirmaries in May 1891, and continued up to November. In both Institutions the total number of cases amounted to 356, and the deaths to 56. According to Dr. Savill, Superintendent of the Paddington Infirmary, there were two types of the disease observable, a dry type, and a moist type. The primary attack lasted from six to ten weeks, and relapses were common. This curious outbreak was almost exclusively confined to old patients (see *British Medical Journal*, 5th December 1891).

5. *Scabies* or *Itch* is caused by an animal parasite known as the *acarus scabei*, which under the microscope very much resembles the cheese-mite. An adult speci-

men has eight legs, and the head is provided with strong movable mandibles. The eruption on the skin is caused by the burrowing of the acarus for the purpose of feeding and propagation, and is also increased by the scratching due to the irritation induced. It most frequently appears on the flexures of the joints, and generally is first observed between the fingers, and afterwards on the wrists and forearms. It is not so infectious as ringworm, and, as a rule, is only spread from person to person when they sleep in the same bed, but cases have been known of its spreading among school children.

Concluding Remarks.—Having thus far considered in detail, but without any attempt at classification, all the more important communicable diseases, a few words may now be added concerning *channels of infection.* And first, it has to be pointed out that diseases, such as scarlatina, measles, and whooping-cough, which especially attack young children, are almost invariably spread through the agency of schools. Not only are children from infected houses allowed by their parents to attend school so long as they are not prohibited by public officials or the medical attendant, but it often happens that children who are only affected to a slight extent with one or other of these diseases are permitted to go to school as usual, and thus become certain and dangerous centres of infection. But apart from the disastrous results which depend upon the ignorance or reckless indifference of parents in this respect, there can be no doubt too that the agency of schools in the propagation of infectious diseases is becoming all the more potent as attendance becomes better enforced. It is often urged by teachers and school managers that it is no use closing schools to check the further spread of infectious disease, because the children are sure to mingle and play together out of doors. But the conditions are altogether different.

In the open streets there is far more free space, and there is comparatively little risk of inhaling infection from the breath and clothes; whereas at schools the children's caps, bonnets, shawls, and overcoats are hung up together; the children themselves are packed so closely while in school that they must inhale each others' breaths, and have to run all the risks of personal contact; while the dangers are frequently increased by the condition of the outside offices, which in country districts especially are still sometimes of the foulest description, and notoriously neglected.

Among other channels by which infectious disease is frequently spread may be mentioned the occurrence of cases in small shops, or other places of business. Under such circumstances, an attempt is generally made to conceal any cases of the kind as long as possible, because the shopkeeper is afraid of losing his business and frightening his customers. Then, too, there can be little doubt that infectious disease is often spread by tailors and sempstresses, who are allowed to stitch the garment of the fashionable wearer in their own miserable homes, where perhaps a sick child suffering from scarlet fever, measles, diphtheria, or whooping-cough lies covered with rags in a corner of the same room. Indeed, in London and other large towns, there is very little of the actual work of fashionable tailoring or millinery establishments done on the premises; the large bulk of it is taken home by the work-people and finished there. It is to be hoped that the enforcement of the Infectious Diseases (Notification) Act will greatly lessen risk in this direction, but there is no doubt that numerous cases of infectious disease will not be reported, because medical assistance will remain unsolicited.

But there are other channels of infection which operate perhaps even more disastrously than these, and

amongst them may be mentioned the following:—Pawnshops, where articles of clothing from all parts, and mostly from insanitary homes, are huddled and stored together; small laundries, which are scattered round the outskirts of towns; dairymen's premises, when they are not properly supervised and kept in order; and lodging-houses in fashionable health-resorts. People who live in clean and elegant houses, away from the foul breeding-places of infectious diseases, are too apt to forget how closely the dangers press upon themselves, for not only may their clothes be made in these pestiferous localities, but servants, charwomen—"the hewers of wood and drawers of water"—who attend to their wants, either live in the overcrowded slums of our large towns, or have friends or relations whom they visit there. It thus appears that infectious diseases take advantage of almost every relationship of life. The infective material may be left in a cab, communicated in a railway carriage, or be actually inhaled from the breath or infected clothing of the person sitting next one in an omnibus or tramway car.

The wider channels of infection, such as water-supplies and public sewers, have already been fully illustrated, while recent inquiries go to prove that domesticated animals play a far greater part in the propagation of infectious diseases than has hitherto been suspected.

CHAPTER XVI

PREVENTION AND DISINFECTION

Section I.—Preventive Measures

According to Sir John Simon's emphatic dictum already quoted in Chapter I., the causes of preventable disease may be grouped into two great classes, namely, local conditions of filth and nuisance polluting air and water, and reckless dissemination of contagion; and as regards both these wide fields of disease-causation, large powers have been conferred on Sanitary Authorities, and obligations expressly imposed on them by the legislature, to remove the former, and to see that means of isolation and other preventive measures are fully and fairly carried out to control the latter. Improvement of local circumstances, as embraced in all that appertains to sound sanitation, is therefore a most important—and perhaps the most—part of prevention. But though sound sanitation, both in respect to public and private hygiene, may be regarded as the first line of sanitary defence, there are other measures which are of special service in checking the spread of dangerous infectious disease—such as vaccination, means of isolation, disinfection, and compulsory notification. Vaccination, however, only applies to the control of smallpox, and as no such prophylactic method of prevention has been discovered as applicable to any of the other infectious diseases, except perhaps in a very restricted

sense to rabies, we must mainly depend on isolation to protect an always more or less susceptible population. Apart, therefore, from efficient sanitary administration, local authorities cannot be regarded as having discharged their duties to the public unless they have provided hospital accommodation and means for disinfection, either separately, or in conjunction with neighbouring authorities, and have also invested themselves with statutory powers to compel the notification of all cases of dangerous infectious disease occurring within their districts.

1. *Hospital Isolation.*—The kind and amount of hospital accommodation required to meet the wants of differently circumstanced sanitary districts, together with plans, have already been discussed in Chapter XIV., and though it may be true that the great majority of large urban Sanitary Authorities have already made provision in this direction, it is notorious that many of the hospitals were hurriedly erected under the pressure of an epidemic, generally of smallpox, and that the accommodation which they furnish is of an incomplete and temporary character. Moreover, in respect to rural and small urban districts throughout the country, it may be said that very little provision of any kind has been attempted; indeed, there can be no doubt that this question of hospital accommodation can only be satisfactorily and economically solved, so far as these districts are concerned, by conferring adequate powers on County Councils to purchase existing hospitals and erect new hospitals in localities best suited for the distribution of the surrounding population.

Although it is possible to isolate almost any case of dangerous infectious disease in a good-sized house, it is generally admitted that home-isolation in the dwellings of the artisan and labouring classes cannot be carried out, as a rule, without risk of spreading disease. Hospital isolation should, therefore, be urged whenever practicable

for all cases which cannot be safely treated at their own homes, but unless under very exceptional circumstances no patient should ever be removed without the concurrence of the medical attendant, and it should always be remembered that removal can only be legally enforced under Section 124 of the Public Health Act, 1875.

As regards the special diseases for which isolation hospitals are deemed necessary, there is a general agreement that sufficient accommodation should be provided for cases of smallpox, typhus fever, and scarlatina. But in hospitals based on the plans issued by the Local Government Board, it is also possible, and always desirable, to be able to isolate cases of diphtheria and enteric fever. It is very doubtful, however, whether hospital isolation would be of any material assistance in checking the spread of either measles or whooping-cough, partly because these diseases are treated by the public with such utter unconcern, and because, as they attack very young children, there would be the greatest objection to removal on the part of parents. But for very urgent or exceptional cases there is no reason why the small wards of a hospital should not be made available.

2. *Public Provision for Disinfection.*—It has already been pointed out in Chapter XIV. that a disinfecting chamber with all proper appliances should form an adjunct to every hospital. But even in districts where no hospital accommodation has been provided, a disinfecting station, or, for rural districts, a movable apparatus would be of the greatest advantage in securing thorough disinfection of bedding, mattresses, and articles of clothing, and full power is given to all Sanitary Authorities to make such provision. They are also empowered to disinfect rooms free of charge, and to supply disinfectants liberally to all who cannot well afford to buy them. The powers and obligations of Sanitary Authorities in respect to isola-

tion and disinfection, and the duties of Health Officers as regards prevention generally, will be more fitly discussed in the concluding chapter.

3. *Notification.*—As it is essential to prompt preventive action that early information should be obtained of the occurrence of every case of dangerous infectious disease, it is incumbent on all Sanitary Authorities to adopt the Infectious Diseases (Notification) Act of 1889. Previous to the passing of the Act, compulsory notification had been in operation in several large towns under special Local Acts, but the Act of 1889 rendered notification compulsory in London, and placed it within the reach of all other Sanitary Authorities throughout the country, whether urban or rural. Although the Act was thus to a large extent an adoptive Act, the advantages which it conferred were so manifest that it has been adopted by the great majority of Sanitary Authorities, and it is to be hoped that an Amending Act will soon be passed to render notification compulsory throughout the country. Among the advantages which notification confers are the following:—

(1.) Early information of all cases of notifiable disease, and therefore an accurate knowledge of disease prevalence and distribution in a district.

(2.) Opportunity afforded of inquiring into the probable causes of infection, whether through direct infection, as in the household, or during a visit, or through school agency; whether associated with any insanitary conditions of premises or quality of water-supply; whether conveyed by milk or other articles of food, etc. It is only by the comparison of data afforded by inquiry into the particulars of each case notified, that outbreaks depending upon water-supplies, milk-supplies, infected schools, or other common origin, can be detected and checked.

(3.) Power to secure prompt removal to hospital, if

that is practicable, and to enforce the provisions of the Public Health Act and the Infectious Diseases (Prevention) Act with respect to isolation, quarantine, and disinfection.

Unfortunately the Infectious Diseases (Prevention) Act of 1890 is also an adoptive Act, but, as will be shown subsequently, it contains several very important clauses bearing on milk-infection and disinfection, and should therefore be adopted by all Sanitary Authorities.

4. *Quarantine.*—This term, which bears an old-world significance of isolation for a period of forty days, is variously applied in respect to modern preventive measures. In foreign countries it refers to the detention of persons on board ship or in camps, to prevent the invasion of cholera, or other dangerous infectious disease. If, for example, a ship arrives at a foreign port with cholera cases on board, some Governments require that the whole of the crew and passengers, healthy as well as sick, shall be detained on board ship until such time as the vessel is declared free from infection. Or, if the disease has obtained a footing in the country, they may forthwith proceed to form *cordons sanitaires,* with a view of preventing people leaving the infected district. Or, again, if travellers from an infected district in another country cross the boundary of a neighbouring country, they may be subjected to all the annoyance of detention until the supposed period of incubation has passed; or if cases crop up amongst them, they may be detained for an indefinite period. At ports in the Mediterranean, all passengers on board suspected vessels must be landed and isolated for from three to six days, while if the ship is infected, there must be five days' detention.

That such a system of quarantine is as impotent as it is vexatious and inhuman has been proved again and again, inasmuch as quarantining countries are essentially

the countries which cholera invades. For apart from the interference with commerce and the horrors of isolation camps which it entails, the system has a blighting effect on all sanitary progress in the countries in which it is enforced, just because reliance is placed solely on detention and *cordons sanitaires,* and not on improved sanitation, which alone constitutes the true basis of sanitary defence. This was the view which was so strongly advocated by Dr. Thorne Thorne in his official capacity as delegate from Great Britain at the Sanitary Congress held in Rome in 1885, and it was strongly supported by the delegates from the United States, India, and several northern countries.

Quarantine on these rigid lines has long since been abandoned by this country, because reliance is based on sound sanitation, and the only other preventive measures required are inspection of vessels, removal of the sick to hospitals, and disinfection.

But quarantine in a less restricted sense is often of immense advantage in preventing the spread of infectious disease. For example, in some towns, as in Leicester, quarantine stations are provided for the reception of persons from an infected house after removal of the patient to hospital, where they are maintained free of charge until the incubation period has passed; and in the meanwhile the house and its contents are thoroughly disinfected. Such stations are usually attached to the isolation hospitals, and the plan has been adopted more particularly as a protection against the spread of smallpox. But under the Infectious Diseases (Prevention) Act, Sanitary Authorities are compelled to provide, free of charge, temporary shelter for the members of any household who may be required to leave their dwelling while disinfection is being carried on. Although such provision is not ostensibly made for quarantining the household, it

might, under exceptional circumstances, be readily utilised for that purpose.

In districts without isolation hospitals it often becomes necessary to carry out a somewhat strict kind of quarantine in respect to an infected household. If, for instance, a child is suffering from a disease which the father is likely to disseminate, he should be kept from work, and be paid to stay at home and assist as a nurse. Indeed, under the heading of expenses for nursing, a Sanitary Authority may not only pay for a nurse, but also pay for a messenger to carry food and other articles to the house, if it be deemed necessary to quarantine the whole household during the illness. Liberal payment to the bread-winner under these circumstances is always desirable, because it enables the sanitary officials to carry out protective measures which they would have considerable difficulty in legally enforcing, and if the cost is sometimes considerable, it is but poor compensation for hardships which would otherwise be avoided if hospital accommodation were always available. Then, again, in rural districts it is sometimes possible to stamp out an outbreak by hiring an infected house, if it should happen to be large enough, for purposes of isolation, and removing any other cases which may crop up to this temporary hospital. On more than one occasion I have advised such a course to be pursued, and with the best results, while the cost entailed was comparatively trifling.

After a patient has been removed to hospital and the sick-room and its contents have been disinfected, it is only necessary to keep the household under observation during the maximum period of incubation of the special disease which has been notified, although in the case of children it is always wise to allow a good margin before permitting their return to school. If, on the other hand, the case is treated at home, the household must be kept

under a certain degree of quarantine, varying according to the nature of the disease, until the last case has been pronounced free from infection, and final disinfection has been thoroughly carried out. In fixing the exact date when disinfection can be completed, it is always advisable, whenever possible, to be guided by the medical attendant.

It need hardly be said that during the quarantine period no children from an infected house ought to be allowed to attend school, though generally an exception may be made in respect to enteric fever. Exception should also be made as regards certain diseases which are often troublesome in schools, such as ophthalmia, mumps, impetigo, or ringworm. In these cases it is only necessary to detain the patient at home until complete recovery is assured. Quarantine in a more or less restricted form should also be insisted on as regards special occupations, notably milk-dealing, tailoring, dressmaking, and washing, when these employments are carried on in the infected house. Tradespeople, as a rule, have a great objection to notification, because they believe that publicity will injure their business; but in small towns or villages the cases are sure to become known even if they are not reported, and any attempt at concealment will render them liable to proceedings, especially if the Notification Act is in force in the district. Notification should always be regarded as privileged information, and besides, by adopting prompt measures and paying a poor washerwoman or seamstress to nurse her sick household during the illness, not only may much-needed assistance be afforded for the time being, but customers will duly appreciate the precautions which have been taken, and will readily renew their custom after all risk of infection has passed. Further, the Medical Officer of Health will have no hesitation in certifying that every care has been taken; whereas, if concealment has been attempted and

is discovered, it often becomes his disagreeable duty to advise that proceedings should be taken either for neglecting to notify, or for exposure of infected children, or of infected articles. On the whole, then, it is greatly to the advantage of small tradespeople that early information of infectious cases should be given to the sanitary officials, even in districts where the Notification Act is not in force, because they at once obtain the best advice concerning the precautions which should be taken, and every assistance to enable them to carry on their business if that is possible, or to resume it when all risk to the public has passed. In other cases it is sometimes necessary to inform employers or other persons if there is reason to believe that due precautions are neglected.

5. *Closure of Schools.*—As infectious disease is frequently spread through school agency, Article 98 of the Education Code renders it incumbent on the managers of public elementary schools to "comply with any notice of the Sanitary Authority of the district in which the school is situated, requiring them for a specified time, with a view to preventing the spread of disease, either to close the school or to exclude any scholars from attendance, subject to an appeal to the Education Department, if the Managers consider the notice to be unreasonable." Sanitary Authorities, however, have no power to interfere with Sunday schools, dames' schools, or other private schools, except in so far as they may contravene clause 91 of the Public Health Act in respect to nuisance or overcrowding, or clause 126, in respect to the spread of infection; but if the Medical Officer of Health deems it necessary that any of these should be closed for a stated time, he will always, as a rule, meet with a ready acquiescence with his instructions.

If the Notification Act is in force in a district, and isolation in hospital is available, it will seldom be neces-

sary to close schools for prevalence of any of the notifiable diseases except scarlatina or diphtheria. In outbreaks of these diseases, however, it often happens that the early cases are of such a mild character that no medical attendant is called in, and thus either disease may assume considerable proportions before its existence is suspected. It is on this account that teachers should always be advised to exclude from school any children suffering from throat symptoms or signs of feverishness, and they should also be supplied with addressed and stamped forms in order that all such cases may be promptly notified to the Medical Officer of Health. On the other hand, communications should be sent to the teacher of each school attended by children from an infected house, intimating the occurrence of the case and the nature of the disease, and requesting that such children shall be excluded until a certificate of safety is forwarded after final disinfection and termination of the period of quarantine.

Such co-operation on the part of sanitary officials and teachers will often obviate the extreme measure of closing a school by simply excluding all suspected children, and all children from houses known to be infected. Then, again, it is often possible to obviate complete closure by excluding children from particular streets, or, in country districts, from particular hamlets; or, should measles or whooping-cough be the particular disease against which precautions have to be taken, it may be advisable only to close the infant department of a school. Indeed, it may be said that these two diseases, and especially measles, are far more liable to be spread through school agency than any of the other diseases, partly because they are both infectious before the characteristic symptoms appear, and because they have not been deemed of sufficient importance to be scheduled as notifiable dis-

eases. Measles, however, has become a far more fatal disease than scarlatina, and school closure, especially in country districts, is the only effective measure which can be adopted to check its spread. But with regard to all of these diseases, school closure is attended with far better results in rural districts than in towns, because the pupils are scattered over a wide area, and the school is often the only focus of infection. On the other hand, it is obvious that, in more populous localities, if schools were to be closed whenever an infectious disease becomes prevalent, there are many towns in which the schools would hardly ever be open.

In respect to towns, it should also be noted that, if an outbreak of disease is confined to the scholars of one particular elementary school, it may be sufficient to close that school only. But where different schools have all appeared to aid in the spread of disease, though perhaps to an unequal extent, it may be considered advisable that all should be closed, not only for the sake of appearing to deal with all impartially, but also lest children in an infectious state, who previously attended the schools that are closed, should be sent to others that might remain open.

But apart from the exigencies of school closure depending upon the prevalence of infectious disease among children, it is sometimes necessary to close a school on account of infectious illness in the teacher's household, and also, for short periods, to permit of the rectification of any sanitary defects of a nature to extend disease, or in order that the school may be disinfected. According to the Memorandum of the Local Government Board, issued in 1890, from which the above remarks have been summarised, these temporary and occasional closures of schools are contemplated in the article of the Education Code already quoted, and are to be regarded as having a real importance of their own.

The sanitary condition of schools, it need hardly be said, should always receive the closest attention of the Medical Officer of Health, for though the Government grant is supposed to be conditioned by sound sanitation in respect to ventilation, overcrowding, warming, lighting, water-supply, drainage, and scavenging, it too often happens that serious defects, especially in respect to outside offices, are overlooked by the Government School Inspectors, just because they assume that these matters should come under the cognisance of the Sanitary Authority. It would be far more satisfactory, and would remove the tendency to the somewhat lax inspection of these details attending a divided responsibility, if the Education Department, before awarding the grant, should insist on a certificate of satisfactory sanitary condition, signed by the Medical Officer of Health, at the same time reserving to the School Inspectors the right of making any representations which they may deem advisable. In rural districts the sanitary condition of the outside offices is often very faulty as regards structural details, and where large ash-pit middens or privies are still permitted, the scavenging is seldom properly attended to. A dry system of conservancy and systematic scavenging can alone be considered satisfactory where trough-closets or water-closets cannot be introduced. When there is any tendency to diarrhœal prevalence, thorough scavenging should be insisted on, and disinfectants freely used.

When there is threatened prevalence of infectious disease in any district, the schools should invariably be visited. Incipient cases may thus be frequently detected, and in respect to scarlatina, children in the peeling stage may often be discovered. The teacher should keep a list of all cases which it may be necessary to exclude, together with the dates indicating the period

of exclusion, and if such list is attested by the signature of the Medical Officer of Health, there is no difficulty in obtaining the grant for average attendance.

In rural districts it should be laid down as an instruction to sanitary inspectors that whenever they visit a village, they should always make inquiries at the school concerning the health of the children, and should also inspect the outside offices. It may also be observed here that disease prevention in these districts would be greatly assisted if the sanitary inspectors were appointed the school attendance officers instead of the relieving officers, who in most districts hold these appointments. The duties of the school attendance officer are far more closely allied to those of the sanitary inspector, and besides, the visits of the relieving officer have attached to them an implied taint of pauperism which it is manifestly unfair to inflict on the non-pauper class.

As regards the period during which it may be deemed necessary to close a school for the purposes of disease prevention, it may be laid down as a rule, especially in respect to outbreaks of scarlet fever, diphtheria, measles, or whooping-cough, that it is practically useless to certify closure for any period shorter than three weeks, and even at the end of that period it will frequently be necessary to issue a fresh certificate to continue closure. But before reopening or issuing a fresh certificate, the Medical Officer of Health should consult the medical practitioners of the district; and this is more particularly advisable with regard to outbreaks of measles or whooping-cough, and in districts which may not have adopted the Infectious Diseases (Notification) Act.

The Association of Medical Officers of the large public schools in England have advised the following periods of isolation and quarantine in respect to the several diseases tabulated :—

	Quarantine to be required after last exposure to infection.	Earliest date of return to School after an Attack.
Smallpox .	18 days	When all scabs have fallen off.
Chicken-pox .	18 ,,	Ditto.
Scarlet fever .	14 ,,	Six weeks, and then only if no desquamation or sore throat.
Diphtheria .	12 ,,	Three weeks, if convalescence is complete, and no sore throat, albuminuria, or discharges remain.
Measles .	16 ,,	Three weeks, if all desquamation and cough have ceased.
Whooping-Cough .	21 ,,	Six weeks from the commencement of the whooping, if the characteristic spasmodic cough and whooping have ceased. Earlier, if all cough be gone.
Rötheln .	16 ,,	Two to three weeks, according to the nature of the case.
Mumps .	24 ,,	Four weeks, if all swelling have subsided.

Neither enteric fever nor typhus fever is included in this list, but in respect to both of them it may be said that the quarantine after exposure should not be less than three weeks, and the earliest date of return to school only after complete recovery.

In diseases such as ophthalmia, impetigo, ringworm, or scabies, exclusion from school should be insisted on till complete recovery is certified.

Section II.—Disinfectants and Disinfection

In the strict use of the term, a *disinfectant* may be defined as an agent which kills or renders inert the specific virus of any infectious disease. In the bacteriological sense, therefore, it may be regarded as synonymous with the term "germicide," or "bactericide." But whether the infective material is a living organism or

the product of a living organism, disinfection should be restricted in its application to mean the destruction of the *activity* of both the organism and its product. An *antiseptic*, on the other hand, is a substance which arrests putrefactive change, or impedes the growth of micro-organisms without destroying their vitality; while a *deodorant* is a substance which destroys or masks offensive effluvia, so as to render them imperceptible, or less perceptible, to the sense of smell. All disinfectants act also as antiseptics even when they are used in insufficient quantity or degree to destroy infective activity, and they may also act as deodorants, inasmuch as effluvia are frequently the by-products of bacterial growth.

There is every reason to believe that the activity of most, if not all, of the contagia is destroyed when they are freely exposed and diluted with fresh air. The virus of typhus fever, for example, is only dangerous to those who come in close contact with the patient, or in badly-ventilated and overcrowded sick-rooms. On the other hand, there is strong probability that the contagium of smallpox may be wafted for considerable distances around a hospital, and more particularly when it is crowded with severe cases. But the mere fact that severe epidemics of highly infectious diseases, such as measles, influenza, and whooping-cough, entirely disappear for a time is proof that a large amount of contagium becomes inert without the aid of artificial disinfection. If, therefore, confined air is often the medium by which the specific contagia are conveyed, plentiful dilution with fresh air greatly lessens the risk of infection, and hence the importance of free ventilation, both in respect to the sick-room when occupied and as a valuable aid to disinfection afterwards.

But in addition to the effects of mere dilution, it is probable that the oxygen in the air exercises a direct

chemical action on infective material, while other atmospheric conditions, such as dryness, temperature, and sunlight, play an important part. Thus, Koch has stated that drying is fatal to the comma bacillus of Asiatic cholera, and it is generally conceded that the contagium of yellow fever is destroyed by cold. These natural aids, however, cannot be regarded as affording any reliable protection against infection, and they must therefore be supplemented by artificial means.

1. *Disinfection by Heat.*—While extreme cold prevents putrefactive change, and therefore acts as an antiseptic, extreme heat is destructive of all organic matter, and combustion is the most efficacious, as it is the most ancient, of all methods of disinfection. As regards infected articles of small value this is still the safest plan to pursue, but true disinfection may usually be effected by exposure to moist or dry heat at a sufficiently high temperature. Thus, the late Dr. Henry proved experimentally that the vaccine virus was deprived of the power of reproduction when exposed for three hours to a temperature of 140° Fahr., while a temperature of 120° failed to produce this effect. As a result of these and other experiments, he was the first to recommend the employment of the hot-air chamber to disinfect clothing, bedding, and the like. These experiments have been further extended by various observers from time to time, and notably by Dr. Koch in Germany, and more recently by Dr. Franklin Parsons and Dr. Klein in this country. (See *Annual Report of the Medical Officer of the Local Government Board*, for 1884.) As Dr. Parsons's report has been published separately, it will be sufficient here to indicate very briefly the basis and methods of procedure, and the principal conclusions arrived at. In the first place it was necessary to determine by an extended series of experiments what

was the special virus or contagium which was the most resistant to every form of heat, and after trying the virus of swine-plague, tuberculosis, and anthrax,—all of which admit of being tested on animals before and after exposure to various degrees of heat,—Dr. Parsons and Dr. Klein, who was associated with him in the inquiry, satisfied themselves that the virus of anthrax was the most resistant. Having settled this point, they were able to proceed on the assumption that such apparatus or arrangements as would yield a heat sufficient to destroy the anthrax virus, not only in its bacillar but in its spore form, might be relied upon to destroy the potency of infectious matter generally. In experimenting upon the efficiency or otherwise of the various kinds of apparatus which have been constructed for this purpose, it was seen to be necessary that the heat generated should penetrate bulky and non-conducting articles, while at the same time it would not injure or destroy the most delicate fabrics. Dr. Parsons's main conclusions are briefly these:—

(1.) It may be assumed that the contagia of the ordinary infectious diseases of mankind are not likely to withstand an exposure of an hour to dry heat of 220° Fahr., or one of five minutes to boiling water or steam of 212° Fahr.

(2.) Dry heat penetrates very slowly into bulky and badly conducting articles, as of bedding and clothing, the time commonly allowed for the disinfection of such articles being insufficient to allow an adequate degree of heat to penetrate into the interior.

(3.) Steam penetrates far more rapidly than dry heat, and its penetration may be aided by employing it under pressure, the pressure being relaxed from time to time, or in a current, so as to displace the cold air in the interstices of the material.

(4.) When dry heat is used, scorching begins to occur at different temperatures with different materials, white wool being soonest affected. It is especially apt to occur when the heat is in the radiant form. To avoid risk of scorching, the heat should not be allowed to exceed 250° Fahr., and even this temperature is too high for white woollen articles.

(5.) Steam disinfection is inapplicable in the case of leather, or of articles which will not bear wetting.

(6.) For articles that will stand it, boiling water may be relied on as an efficient means of disinfection. It is necessary, however, that before boiling, the grosser dirt should be removed by a preliminary soaking in water, because a high temperature whether moist or dry fixes organic stains indelibly in textile materials. This should be done before the linen leaves the infected place.

(7.) The articles for which disinfection by dry heat or steam is especially applicable are such as will not bear boiling in water, *e.g.* bedding, blankets, carpets, and cloth clothes generally.

(8.) The most important requisites of a good apparatus for disinfection by heat are (*a*) that the temperature of the interior shall be uniformly distributed; (*b*) that it shall be capable of being maintained constant for the time during which the operation extends; and (*c*) that there shall be some trustworthy indication to the actual temperature of the interior at any given moment.

(9.) In dry heat chambers, and more especially those heated by coal or coke, the first and second requirements are very often far from being fulfilled, and in very few of them did the thermometer with which the apparatus was provided afford a trustworthy indication of the temperature of the interior.

(10.) In steam apparatus, the three requirements above mentioned are all satisfactorily met, and for this

reason, as well as for the great rapidity and certainty of action by steam, Dr. Parsons holds that steam chambers are greatly preferable to those in which dry heat is employed.

(11.) It is important that the arrangement of the apparatus, the method of working, and the mode of conveyance to and fro should be such as to obviate risk of articles which have been submitted to disinfection coming into contact with others which are infected.

(12.) After carefully experimenting with various apparatus, Dr. Parsons mentioned the following apparatus, existing at the date of his report, as giving the best results of any in their respective classes:—Of the apparatus heated by coal, the newer machine, patented by Bradford and Co., Salford, Manchester; of those heated by gas, the Nottingham self-regulating apparatus, invented by Dr. Ransome, F.R.S., and manufactured by Messrs. Goddard and Massey, Nottingham; and of those employing steam, Washington Lyon's patent steam disinfector, manufactured by Messrs. Manlove, Alliot, and Co., Nottingham.

These general conclusions, especially in respect to the great superiority of steam disinfection over the hot air process, have been amply verified by extended observation, and notably by a series of very careful experiments conducted by Dr. Whitelegge, Medical Officer of Health for the West Riding of Yorkshire, and Dr. Ashby, Medical Officer of Health for Reading. By means of an electric thermometer, set to ring at 212° Fahr., and placed between sixteen or more layers of blanket, they found that in a steam apparatus the maximum interval of heat penetration indicated by the ringing of the bell was seventeen minutes; while in a hot air chamber with twelve layers a penetration temperature of only 196° was reached after eight hours' interval, although the inlet temperature was 255°, and the outlet 245° to 250°. It therefore

appears that in the best devised hot air apparatus the penetration of heat is so slow that it is practically impossible to thoroughly disinfect articles of moderate thickness, such as pillows or mattresses; and on this account, as well as for rapidity in action, steam disinfection should be adopted for all disinfecting stations.

Of the several kinds of apparatus, now in actual use, the three which merit special notice are Washington Lyon's steam disinfector; the apparatus manufactured by Goddard, Massey, and Warner, of Nottingham; and the apparatus of Van Overbeek de Meyer of Leyden.

(1.) Washington Lyon's apparatus consists of a strong iron chamber, oval in section, with double walls of boiler plate, and a tightly-fitting door at either end which shuts against an indiarubber collar, and is secured by screw handles so as to form a steam-tight joint. From the boiler, which is detached from the apparatus, steam is admitted first into the hollow casing or jacket, and afterwards into the interior of the chamber. The apparatus is usually worked with a pressure of ten lbs. per square inch in the jacket and five lbs. in the chamber, so that the steam in the latter is superheated in order to obviate condensation. The jacket and casing are each provided with a safety valve and pressure gauge, by which the pressure of steam, and therefore the temperature, can be ascertained at any moment. After the articles have been introduced and the doors securely closed, steam is first sent into the jacket so as to heat the contents of the chamber, and is then admitted into the chamber until the gauge marks the desired temperature. It is found that penetration is more rapid if the pressure is intermitted once or twice, which is readily effected by a turning cock. At the end of fifteen or twenty minutes the bulkiest articles are found to be thoroughly disinfected. The steam is then

shut off from the chamber, but allowed to circulate for two or three minutes in the jacket, and further drying may be effected if necessary by leaving the door ajar for a short time before the articles are removed.

(2.) The apparatus of Goddard, Massey, and Warner resembles Washington Lyon's in most respects, but differs from it in the following particulars:—The chamber is rectangular, not oval in section; the doors are hollow, and by means of a jointed pipe are connected with the casing so that they form part of the steam-jacket; a separate boiler is dispensed with, the boiler being formed by the lower portion of the jacket underneath which the fire is placed; the pressure in the boiler and jacket is therefore the same—usually about twenty lbs. After the steam in the jacket has reached the working pressure, the articles are placed in the chamber and the doors are shut and secured. By means of a steam-jet at the outlet, hot air is first drawn through the chamber for two or three minutes, steam is then turned on from the jacket-boiler, which soon reaches its full pressure, and after ten to twenty minutes, according to the nature of the articles, the steam is allowed to escape and hot air is again drawn through the chamber to dry the articles.

(3.) The apparatus of Van Overbeek de Meyer, is simpler in construction than either of these two. The steam is generated in a jacket-boiler which surrounds the chamber, into which it is admitted through an opening at the top, but as it is not under pressure, less strength of material is required, and safety-valves or pressure-guages are dispensed with. Owing to its lighter specific gravity, the steam does not mix with the cold air in the chamber but displaces it, and drives it out through an opening at the bottom. Although the temperature does not exceed 212° Fahr., the penetration, according to Dr. Whitelegge, appears to be little less rapid than at

the higher temperature and pressure used with the other two forms of apparatus. On account of its cheapness, De Meyer's apparatus appears to be specially applicable for a small district or institution. Among other steam apparatus which have so far stood the test of experiment may be mentioned a steam disinfector, manufactured by Benham and Sons of London, and a cheap disinfector by Thursfield of Vienna.

For these and any other form of apparatus of a stationary kind it is essential that there should be a door at each end opening into entirely separate rooms provided with separate entrances. In other words, the apparatus must be built in a divisional wall completely separating the two rooms, one of which should receive the infected articles, and no article should be allowed to enter the other room except through the disinfecting apparatus.

Several forms of apparatus of a portable kind have been devised for use in scattered rural districts, but hitherto it does not appear that any such apparatus has been fairly tried.

2. *Chemical Disinfection.*—Previous to the researches of Koch and others, no precise knowledge existed concerning the relative values of the numerous chemical agents which were indiscriminately used for disinfecting purposes. Indeed, it may be said that very few of them have been found to act as true disinfectants, while the great majority of them can only be classed as antiseptics or deodorants. The method of testing their efficiency pursued by Koch was as follows:—Threads were soaked in cultures of the spores of anthrax and other bacteria, and after being dried were placed in disinfecting solutions of various strengths and for stated periods. After this treatment, or presumed disinfection, there was final testing by cultivation or inoculation experiments, and out

of a long series the following solutions only were found to have destroyed the activity of anthrax spores within a single day :—

Mercuric Chloride . . .	1 per cent solution.	
Carbolic Acid . . .	5 ,, ,,	(not in all cases.)
Potassic Permanganate .	5 ,, ,,	
Bromine Water . . .	2 ,, ,,	
Osmic Acid . . .	1 ,, ,,	

Chlorine water and iodine water were also found to be efficacious when sufficiently saturated, but a 4 per cent solution of carbolic acid took three days, and a 1 per cent solution of permanganate had not acted at the end of two days.

Among popular disinfectants a 5 per cent by weight solution of the following either took several days to kill anthrax spores, or altogether failed to do so :—Chloride of lime, chloride of zinc, sulphate of zinc, sulphate of copper, sulphate of iron, boracic acid, etc. These, and a long list of other substances, can therefore only be classed as antiseptics or deodorants. At the same time, it does not follow that a substance is inert against the contagia of the common human infectious diseases because it fails to kill the highly resistant spores of the bacillus anthracis, but in preferring an agent which will destroy the latter, we know we are on safe ground.

(1.) *Mercuric Chloride,* or *Corrosive Sublimate.*—For the chemical disinfection of excreta and soiled linen, corrosive sublimate is, by general agreement, admitted to be the most efficacious and suitable. A solution of 1 part per 1000 is found to destroy anthrax spores. In using it, however, three precautions have to be borne in mind. In the first place, it is exceedingly poisonous, and the solution should therefore be coloured and kept in fluted bottles, labelled as poison. In the second place, as it

corrodes iron and other common metals, and is instantly decomposed by them, it must be used in non-metallic vessels. In the third place, it forms an inert insoluble compound with albumen, and to obviate this the solution should be acidulated. In the Memorandum issued by the Local Government Board on the proceedings which are advisable in places attacked or threatened by epidemic disease, it is recommended that a suitable solution may be made as follows:—Dissolve half an ounce of corrosive sublimate, one fluid ounce of hydrochloric acid, and five grains of commercial aniline blue in three gallons of water. For convenient use, however, a saturated solution of the above quantities of 1 in 10 should be prepared and kept in fluted bottles, so that each bottle, when mixed in a bucketful of water (three gallons) will yield a solution of the required standard. A solution of corrosive sublimate possesses this great advantage, that besides being the most effective disinfectant, it does not rot or stain linen steeped in it.

What is known as *St. Bede's Disinfectant* has been strongly recommended by Dr. Klein as a convenient preparation containing corrosive sublimate. It is sold in small solid blocks, four of which should be dissolved in a gallon of water to make up the required strength of the solution. Another preparation which has been strongly recommended is one of the *Sanitas* preparations, known as *mercuric germicide.*

(2.) The several *halogens* — chlorine, bromine, and iodine—according to the experiments of Koch, Cash, and Fischer, may also be classed as true disinfectants; but chlorine is the only one which has been fairly tried in practical disinfection.

(3.) *Carbolic Acid.*—Although carbolic acid is more especially an antiseptic, Koch has recommended a 5 per cent solution for disinfecting the excreta and soiled

linen of cholera patients. Phenol, cresol, creolin, Jeyes' compounds, and other substances allied to carbolic acid, may all be classed under the category of antiseptics and deodorants.

(4.) Chloride of lime is a useful disinfectant for excreta, but too strong a solution injures clothing.

(5.) *Permanganate of Potash* can only act as a disinfectant if present to the extent of 5 per cent of the whole weight of the liquid in which it is mixed, after oxidation of the organic matter. The action, therefore, of permanganate, and the solution of it known as *Condy's Fluid*, consists really in deodorisation and partial oxidation of organic matter.

3. *Antiseptics and Deodorants.*—Apart from surgical purposes, antiseptics are used for the preservation of food, to prevent putrefactive change in organic matter, and for many other purposes. The preservation and conveyance of meat in freezing chambers is an instance of the value of extreme cold as an antiseptic. As already pointed out, all true disinfectants act also as antiseptics, but there is a long list of other reagents which, though they arrest or retard microbial growth, are not necessarily germicidal. In this category may be included certain inorganic substances, such as borax, boracic acid, and several mineral acids; almost all the essential oils, as turpentine, eucalyptus, peppermint, and cloves; alkaloidal substances, such as quinine; and other organic compounds, such as alcohol, salicylic acid, hydrocyanic acid, and aniline. Terebene, sanitas, Jeyes' disinfectants, and other well-known preparations may also be added to the list.

Although actual disinfection of sewers and drains cannot be accomplished as such, antiseptics, such as carbolic acid, Jeyes' fluid, or sanitas, are very useful by being employed in them at times, and when used

in water-carts are very advantageous in cleansing and deodorising filthy courts, lanes, and narrow streets.

Among solid deodorants, dried earth, charcoal, quicklime, chloride of lime, and sulphates of iron, copper, and zinc may be mentioned. Charcoal possesses exceptional powers of absorbing gases and offensive odours, and oxidises very rapidly almost all oxidisable matters with which it comes in contact. Quicklime absorbs carbonic acid gas, and possibly also sulphur compounds. Chloride of lime is a very powerful deodorant, and, as already stated, can also act as a true disinfectant. The sulphates of iron, zinc, and copper act chiefly by decomposing offensive sulphides. Solution of permanganate of potash is an effectual liquid deodorant, and possesses the advantage of not being poisonous.

Among aerial deodorants, some of which also possess considerable disinfecting properties, the most important are nitrous acid, chlorine, sulphurous acid gas, and ozone.

(1.) *Nitrous Acid*, or *Nitrogen tetroxide*, is evolved by adding strong nitric acid, diluted with a little water, to copper filings. The nitrogen dioxide which is given off takes up oxygen from the air, and the red fumes of nitrous acid are formed. The power of oxidising organic matter possessed by nitrous acid is very great, and no disinfectant will more readily remove the smell of the dead-house. The fumes, however, are exceedingly irritant and dangerous. It has been highly recommended as a disinfectant for infected cow-sheds and pig-styes.

(2.) *Chlorine* decomposes sulphuretted hydrogen and ammonium sulphide, and possesses such a strong affinity for hydrogen that it readily breaks up compounds containing that body. It also acts as a powerful bleaching agent. It has been strongly recommended by Fischer and Proskauer as much more efficacious for the disinfection of empty rooms than sulphurous acid gas, but it

is not so convenient to use, and is more damaging to valuable furniture or decorations. It also appears that the action of both chlorine and sulphurous acid gas is greatly assisted if the air of the room is rendered moist for some time before disinfection. Chlorine is most conveniently evolved by adding strong hydrochloric acid to bleaching powder in the proportion of 3 to 2, and allowing 1 lb. of powder to every 1000 cubic feet of space, or it may be obtained by adding diluted sulphuric acid to chloride of lime.

(3.) *Sulphurous Acid Gas*, or *Sulphur dioxide*, has for centuries back been the favourite disinfecting agent for empty rooms, alike on account of its cheapness and the ease with which it may be applied. It is obtained by burning small pieces of lumps of sulphur, which, in order to obtain the best results, should be well moistened with methylated spirit. Under ordinary circumstances, 1 lb. of sulphur is generally allowed for every 1000 cubic feet of space, and as this yields 11·7 per cent of the gas, it will be seen that the percentage in the contained air is much below what would be required for thorough disinfection. It must, however, be regarded as a valuable aid to the practical disinfection which is carried out subsequently to complete the process. It acts as a powerful deoxidising agent, and decomposes hydrogen sulphide, and also combines with ammonia. It may be noted here that one-pound sulphur cakes, mixed with shavings, and one-pound sulphur candles, are manufactured for convenience in sulphur fumigation.

(4.) *Ozone* may be generated by gradually mixing 3 parts of strong sulphuric acid with 2 parts of permanganate of potash. Although it is a powerful oxidising agent, and destroys organic matter, it does not commend itself for general use.

To sweeten the air of sick-rooms, some one or other

of the liquid preparations which are so commonly used, such as Condy's fluid, sanitas, terebene, or Rimmel's vinegar, may be mentioned.

Section III.—Practical Disinfection

The hygiene of the sick-room and the isolation and nursing of the patient, as well as all general instructions, appertain especially to the province of the medical attendant, but much assistance is afforded, and,—so far as my experience goes,—is welcomed by distributing printed instructions wherever a case of dangerous infectious disease is treated at home. Instead, therefore, of describing in general outline the course to be pursued in practical disinfection, it may be of service to append the following precautionary measures, which were drawn up two years ago by Mr. Fosbroke, now County Medical Officer for Worcestershire, and myself, for use in our respective districts. They are based on the Memorandum of the Local Government Board already referred to, and the Rules issued by the Society of Medical Officers of Health. Although somewhat lengthy, they can be conveniently printed on a stiff card-board folded in three, which is much to be preferred to the ordinary placard form, and not so liable to be thrown aside —

..................SANITARY DISTRICT

Precautions against the Spread of Infectious Diseases

Under the Infectious Diseases (Notification) Act, 1889, cases of the following diseases must be reported to the Medical Officer of Health :—*Smallpox, Cholera, Diphtheria, Membranous Croup, Erysipelas, Scarlatina or Scarlet Fever, and Typhus, Typhoid or Enteric, Relapsing, Continued, and Puerperal, Fevers.*

Although *Measles* and *Whooping Cough* are not included in the above list, it should be remembered that they are both highly infectious, that they are generally spread through carelessness in allowing the sick to mingle with the healthy, and that many of the

following precautions, more particularly with regard to isolation and school attendance, are absolutely necessary to prevent the spread of these very fatal diseases.

I. General Precautionary Measures

To prevent the spread of infectious disease of any kind, it is of the utmost importance that scrupulous cleanliness of person, clothing, and premises should be observed ; that overcrowding should be abated ; that accumulations of filth and manure should be removed ; and that all sanitary defects, such as bad drainage, foul closets of any description, and polluted water-supply should be attended to without delay. If there is any reason to suspect the purity of the well water, or the milk-supply, as in cases of *Typhoid Fever*, *Diphtheria*, *Scarlatina*, or *Choleraic Diarrhœa*, both water and milk should be boiled directly they are received into the house. No protection is afforded by filtering water.

In outbreaks of *Smallpox* it is essential as a special precautionary measure that all unvaccinated persons (unless they have previously had the disease), living in the infected or adjoining houses, should be vaccinated without delay, and that all young persons above ten years of age should be promptly re-vaccinated.

II. Isolation of the Sick

When a case of infectious disease occurs or is suspected, a Medical Practitioner should be immediately sent for, and on no account should the patient be removed from home unless, under medical advice, to a hospital provided for the reception of such cases.

In districts where there is no such accommodation, and where the patient can be safely isolated and treated at home, a room at the top of the house should always, if possible, be selected as the sick-room. The sick-room should forthwith be stripped of all carpets, curtains, and needless draperies or furniture, and kept well ventilated by open windows and a fire if necessary.

As an additional means of isolation, it is advisable to hang outside the door a sheet steeped in a solution of Condy's Fluid, Sanitas, or some other agreeable deodorant.

It is of the utmost importance that none but those in *immediate* attendance on the sick should enter the room, and no visitors should be allowed.

No child from the infected house should be permitted to attend school or mix with other children until the house is disinfected.

III. *Nursing, Cleansing, Disinfection*

Persons in attendance on the sick should by preference wear cotton dresses, and should frequently wash their hands with disinfectant soap and water. They should, as far as possible, avoid associating with others.

All spoons, glasses, cups, and other vessels should be scrupulously cleansed after being used in the sick-room.

All discharges from the patient should be received into a vessel containing a disinfectant solution, and be removed from the sick-room without delay. On no account should they be thrown into a common closet or ashpit midden without previous disinfection, and where practicable they should be buried in the garden, and as far as possible from the well. This is especially necessary in outbreaks of *Smallpox*, *Scarlatina*, *Typhoid Fever*, and *Choleraic Diarrhœa*.

In wiping the discharges from the nose and mouth in cases of *Scarlatina*, *Diphtheria*, *Smallpox*, and even *Measles*, soft pieces of rag should be used, instead of pocket-handkerchiefs, and burned immediately afterwards.

All bed or body linen which has been in contact with the person of the patient should be steeped in a vessel containing a disinfectant solution *before removal from the room*, then soaked in cold water for some hours, and afterwards boiled. No articles from the infected house should be sent away to be washed elsewhere.

In cases of infectious disease with a skin eruption or rash, such as *Smallpox*, *Scarlatina*, and *Measles*, repeated warm baths, under the advice of the Medical Attendant, are necessary to complete the disinfection of the body of the patient during convalescence.

In the event of death from dangerous infectious disease, the body should be enveloped in a sheet wrung out of a strong disinfectant solution, then sealed up in a coffin and buried without delay. It is highly desirable that as few persons as possible should attend the funeral, and none but those required to remove the body should be allowed to enter the infected house.

After removal to hospital, or after recovery or death, when the patient has been isolated at home, all infected mattresses, blankets, bedding, or other draperies should be at once removed to the disinfecting station, if a disinfecting apparatus has been provided.

In districts where no disinfecting apparatus is available, all such articles, as well as the sick-room, should be disinfected by sulphur fumigation. This should be carried out in the following manner:—Spread out and hang upon lines all articles of clothing or bedding, etc. Carefully close, and as far as possible seal up fire-places, windows,

and all crevices and ventilators; then take a sulphur cake or 1 lb. or more of sulphur lumps, according to the size of the room, and put it in a saucer or iron dish supported by a pair of tongs over a bucket of water: then set fire to the sulphur, close the door, and keep the room shut for six hours; after which it should be freely ventilated, the paper, if any, removed, the walls and ceiling lime-washed, and the floor and furniture swabbed with a disinfectant solution.

IV. Disinfectants

The most reliable disinfectant for use in the sick-room for disinfecting discharges, articles of clothing, etc., or for swabbing furniture and floors, is the solution of corrosive sublimate (perchloride of mercury), recommended by the Local Government Board, and this is prepared as follows:—Dissolve half an ounce of corrosive sublimate, one fluid ounce of hydrochloric acid, and five grains of commercial aniline blue, in three gallons (a bucketful) of water. *Non*-metallic vessels, such as wooden buckets or earthenware pans, should be used for the solution, and articles which have been soaked in it should be steeped in water for some hours before they go to the wash. A convenient preparation in which this *poisonous* disinfectant is made up is known as the "St. Bede Disinfectant," and is sold in small solid blocks, four of which should be dissolved in each gallon of water to constitute the required strength of the solution.

A less reliable, though convenient disinfectant solution for the same purpose is prepared by mixing half a pint of carbolic acid in three gallons of water.

For the disinfection of privies, ashpits, middens, manure heaps, or cesspools, etc., chloride of lime should be used in sufficient quantity to destroy all offensive odours.

Although it may not be possible or necessary to carry out these precautions explicitly in every case, it ought to be the duty of every one to strive to do so in all outbreaks of dangerous infectious disease.

V. Penalties

By the Public Health Act, 1875, it is enacted that if any person, while suffering from any dangerous infectious disorder, shall wilfully expose himself (or any other person) without proper precautions, in any street, public place, shop, inn, or public conveyance, or enter any public conveyance without first notifying the owner or driver, or transmits, or exposes without previous disinfection,

any clothing, rags, or other things which have been exposed to infection from any such disorder, shall be liable to a penalty not exceeding £5.

N.B.—Disinfectants will be supplied *gratis*, to those who are too poor to purchase them, on application to

Mr.................................Sanitary Inspector.

Signed,

....Medical Officer of Health.

The more extended legal obligations bearing on disinfection and isolation, embodied in the Infectious Diseases (Prevention) Act of 1890, will be more conveniently noticed in the concluding chapter.

CHAPTER XVII

DISPOSAL OF THE DEAD

One of the most warmly contested questions in the field of sanitary reform which has attracted public attention during recent years has been the disposal of the dead. When cremation was first advocated in this country the opposition to such an innovation on the time-hallowed custom of earth-burial was so strong and fierce that the pioneers of the movement had the greatest difficulty not only in erecting the one crematorium which still exists in England, namely, at Woking, but in devoting it to its use after erection. In the first place, cremation was regarded as a violation of national sentiment, and a shock to one of the most cherished doctrines of religious belief, and in the second place, it was contended, and still is maintained, that it would lead to a large amount of crime which could never be detected. Time and common sense, however, have both assisted in greatly weakening the force of these objections. Even those who are most biassed by misplaced sentiment are beginning to acknowledge that unless when a body is cast into the sea and becomes food for fishes, it must eventually be reduced to its ultimate elements, whether it is cremated or buried in the earth. Moreover, as regards the medico-legal objection, it was forcibly pointed out by Sir Henry Thompson at the recent Congress of Hygiene, that as a result of inquiries addressed to over three hundred coroners it was

ascertained that only 100 exhumations had taken place in England and Wales during the course of twenty years for medico-legal purposes, and only 20 out of that number had been exhumed for suspected poisoning. It may be admitted, therefore, that though the medico-legal objection dwindles into comparative insignificance, it cannot be regarded as satisfactorily disposed of by the proposal of the advocates of cremation to demand a detailed inquiry into the cause of every death by a public official, such as the Medical Officer of Health, and to authorise him to make a post-mortem examination whenever he deemed it desirable. If disposal of the dead by cremation should ever be generally adopted, such a course would become impracticable, and the results negative.

But the main question at issue is not whether cremation may be permitted, but whether in the interests of national health it can lay any claim to be regarded as an imperative sanitary reform. Even admitting that it is in every respect the safest method of disposing of the dead, the advocates of the system have failed to prove that earth-burial, as it is conducted in properly regulated cemeteries, is a danger to the public health. Indeed, it cannot be too strongly emphasised that the great dangers to health lie not in the disposal of the dead, but in the unreasoning sentiment which prompts the retention of the body in overcrowded homes for as long a period as possible, and the neglect to take proper precautions, or to bury speedily in cases of dangerous infectious disease. Neither cremation nor what is called the rational disposal of the dead by burying them in perishable coffins, would assist in lessening these evils, which, after all, constitute the real dangers.

It is worthy of note, however, as significant of the change which has been gradually taking place in public

opinion with regard to cremation, that in a crowded meeting at the recent Congress of Hygiene, held in London, the following resolutions were carried with, at the most, only four dissentients :—

"1. That Governments should be urged to remove all legislative obstacles to cremation.

"2. That Governments be urged to adopt cremation of bodies on the battle-field.

"3. That cremation of the dead is a rational and hygienic procedure, which is especially called for where death occurs from infectious disease."

While no reasonable objections can be raised to the first two resolutions, it can scarcely be said that the last is based upon reliable evidence. Speaking generally, the effect of the proximity of a burial-ground upon health is the same as that of any other accumulation of putrefying animal matter. If a graveyard is overcrowded there is the risk of nuisance effluvia when graves are opened, and pollution of the ground air of houses in the immediate neighbourhood. There are also possible risks of well-pollution, though there are no well-authenticated outbreaks of disease traceable to this cause, but under the conditions imposed by the legislature it may be said that the public health is now duly safeguarded in all these respects.

At the same time it may be conceded that on economical grounds alone the erection of crematories in the cemeteries of all largely populated centres would, if legalised, be of national benefit, while there can be no doubt that the efforts of those who advocate the use of perishable coffins, and who denounce excess in the direction of expensive paraphernalia, should also be encouraged as efforts in the right direction.

Section I.—Mortuaries

As already pointed out, the real dangers to health depend not so much on the method of ultimate disposal of the dead body, but in retaining it, especially in overcrowded homes, often until putrefaction commences, and neglecting proper precautions and speedy burial in cases of infectious disease. If a dead body is exposed to a temperature of 60° Fahr., it will begin to putrefy in three days, and give off offensive gases, and numerous cases of illness have been attributed to this cause alone, apart altogether from specific infection. Indeed it may be laid down as a safe hygienic rule that no dead body can be retained in an occupied room, or in any house which becomes temporarily overcrowded by vacating the room in which the dead body lies, without a certain amount of risk to the health of the inmates, and this risk is obviously greatly increased when death has resulted from a dangerous infectious disease. Hence, speedy removal of the dead and mortuaries are alike necessary, and in both these directions the legislature has imposed important obligations on Sanitary Authorities throughout the country, as will be seen from the following excerpts :—

1. By Section 141 of the Public Health Act, 1875, it is enacted that any Sanitary Authority, whether urban or rural, " may, and if required by the Local Government Board, shall, provide and fit up a proper place for the reception of dead bodies before interment, and may make bye-laws with respect to the management and charges for the use of the same; they may also provide for the decent and economical interment, at charges to be fixed by such bye-laws, of any dead bodies which may be received into a mortuary."

2. It is further enacted by Section 142 that " when the body of one who has died of any infectious disease

is detained in a room in which persons live or sleep, or any dead body which is in such a state as to endanger the health of the inmates of the same house or room, any Justice may, on a certificate signed by a legally qualified medical practitioner, order the body to be removed at the cost of the Local Authority to any mortuary provided by such Authority, and direct the same to be buried within a time to be limited by such order."

3. Although Sanitary Authorities outside London are empowered to provide post-mortem rooms by Section 143 of the Public Health Act, 1875, it is distinctly stipulated that such rooms shall not be in any way connected with a workhouse or public mortuary, and this proviso was deemed necessary to remove any taint of pauperism which might attach to such a situation, or to obviate any suspicion on the part of poor people that the bodies were removed for dissection purposes.

4. In London, and in all other districts in which the Infectious Diseases (Prevention) Act of 1890 has been adopted, Section 8 of that Act renders it illegal to retain an infected body elsewhere than in a mortuary, or in an unoccupied room, without the sanction in writing of the Medical Officer of Health, or of a medical practitioner; Section 9 of the same Act prohibits the removal of infected bodies from isolation hospitals except to a mortuary or for burial if so certified by the Medical Officer of Health or medical attendant; while Section 10 empowers Justices on the certificate of the Medical Officer of Health to order an infected body, or any dead body which is retained in any house or building so as to endanger health, to be removed at the cost of the Sanitary Authority to any available mortuary, and direct the same to be buried within a time to be limited in the order. Unless the friends or relatives do undertake to bury the body within the time ordered, it shall be the

duty of the relieving officer to bury such body, and the Guardians may recover the expenses in summary manner from any person liable to pay them.

Such are the provisions enacted by the legislature to mitigate the prominent dangers connected with the disposal of the dead, but except it be in large towns—and even in them there is a great lack of mortuary accommodation—little or no effort has been made by Sanitary Authorities generally in this direction. It has been suggested by Mr. Burdett in his excellent work on *Cottage Hospitals,* already referred to in Chapter XIV., that not only should mortuaries be provided at all hospitals, but that Sanitary Authorities should contract with hospital managers to receive bodies from overcrowded homes on payment of certain fees or of a fixed annual subscription. It would, however, be of infinitely greater service to the public generally if all Sanitary Authorities were compelled to provide mortuaries wherever they are required, and were empowered to erect these if deemed advisable in any, or every, burial-place or cemetery in their districts. Even in country parishes, the speedy removal of a dead body from an overcrowded home is as necessary as it is in towns, and there could be no insuperable objection to erecting a cheap and simple structure in every churchyard. The body could then be removed in the night-time or early morning without ceremony, and all the expensive paraphernalia, which tell most heavily in humble funerals, could be dispensed with, except simple attendance for the burial-service at the appointed hour.

Section II.—Burial-Grounds, or Cemeteries.

According to the definition laid down in several Acts of Parliament, a cemetery "is a place for the interment

of the dead," or "a burial-ground," and the works connected therewith. The term, therefore, though it is generally applied to large burial-grounds, does not in its legal sense convey any meaning as regards size.

The horrible overcrowding of graveyards which existed in the early part of the century induced the Government in 1840 to appoint a commission to inquire into evils which had only become too palpable, and more especially in localities with constantly increasing populations. Since that date various enactments dealing with the subject have been passed from time to time; and among the more important of them, from the strictly sanitary point of view, may be mentioned the following:—

1. The Cemeteries Clauses Act of 1847 empowered "companies," or burial-boards, to obtain land by compulsory purchase for the construction, drainage, and management of new cemeteries. But there were certain restrictions and conditions imposed by the Act which were intended to safeguard the public health as far as possible, and which merit special notice because they apply to all new cemeteries constructed after that date, and are incorporated with the Public Health Interments Act of 1879.

(1.) No part of a cemetery shall be constructed nearer to any dwelling-house than the prescribed distance, or, if no distance is prescribed, 200 yards, except with the consent in writing of the owner, lessee, and occupier of such house.

(2.) Every part of the cemetery shall be enclosed by substantial walls or railings at least 8 feet high.

(3.) The cemetery shall be efficiently drained, and for that purpose the Company is empowered to drain into any existing sewer with the consent of the persons having management of such sewer, or of the street or lands through which it passes.

(4.) If any stream, canal, reservoir, aqueduct, pond, or watering-place is fouled by any offensive matter from the cemetery, the Company shall forfeit the sum of £50 for every such offence, and in addition to this penalty any person who has a right to use the water so fouled can claim a penalty of £10 during the continuance of the offence.

2. Section 83 of the Public Health Act, 1848, prohibited interments under or within the walls of any churches built after that date, and this clause is re-enacted by the Public Health Act, 1875.

3. Under the provisions of the Burial Act of 1853, Orders in Council were issued as occasion required, to close cemeteries, or burial-grounds, which were proved to have become overcrowded, and if it is desirable to close any existing burial-place, a representation must be made to the Home Secretary for the purpose of obtaining an Order under this Act.

4. By the Public Health Act, 1875, and other Acts, Urban Sanitary Authorities were empowered under certain circumstances to become the burial-boards of their respective districts.

5. The Disused Burial-Grounds Act of 1884 rendered it illegal to erect any buildings upon any disused burial-ground except for the purpose of enlarging a church or other place of public worship. Under the Open Spaces Acts of 1881 and 1887, however, all Sanitary Authorities are empowered to lay out and maintain disused burial-grounds as recreation grounds.

6. The closing of overcrowded burial-grounds, and the extended powers for providing new cemeteries, effected such a gradual and marked improvement in respect more especially to populous localities, that, as has already been pointed out, it may now be said there is no clear evidence of any injury accruing to the public

health under the conditions enforced in modern and well-regulated cemeteries.

7. But overcrowding of a less pronounced, though of quite appreciable degree kept in the meanwhile increasing as regards many of the older graveyards of rural parishes and small country towns, and to remedy these evils, all local authorities throughout England and Wales, whether urban or rural, were empowered, by the Public Health (Interments) Act of 1879, and the Cemeteries Clauses Act of 1847, with which it was incorporated, to acquire, construct, and maintain cemeteries, either within or without their districts, and are compelled to make such provision if required to do so by the Local Government Board. Although the legislature did not specify the cases in which it was thus made incumbent on Sanitary Authorities to give effect to the provisions of the new statute, the Local Government Board, in a memorandum issued in August 1879, laid down the following as circumstances under which action should be taken :—

"(1.) Where, in any burial-ground which remains in use, there is not proper space for burial, and no other suitable burial-ground has been provided;

"(2.) Where the continuance in use of any burial-ground (notwithstanding there may be such space) is, by reason of its situation to the water-supply of the locality, or by reason of any circumstances whatsoever, injurious to the public health;

"(3.) Where, for the protection of the public health, it is expedient to discontinue burials in any particular town, village, or place, or within certain limits."

It is further pointed out that there are other circumstances which might render it necessary or expedient to provide a cemetery, such as inconvenience of access from the populous parts of a district to the existing burial-ground, or the nature of the site, or the character of the

subsoil. All these are conditions into which the Medical Officer of Health of every district is expected to inquire, and wherever it appears to him necessary that a cemetery should be provided, it becomes his duty to report to the Sanitary Authority.

Very often in country parishes, and also as regards small towns, the difficulty is overcome by local effort at the instigation of the Sanitary Authority, either by donation of land for enlarging an existing burial-ground, or by donation of money, to purchase land necessary for the required extension. Failing local action, however, the Sanitary Authority has full power, on application to the Local Government Board, to obtain land compulsorily, and to carry out all works necessary for efficient drainage, and for these purposes can receive donations in money or land, or can borrow money on loan, the principal and interest of which have to be repaid by imposing a special rate on the particular parish or contributory place affected.

On the other hand, if it should appear desirable, upon the above or any other grounds, to close an existing burial-place, a representation must be made to the Home Secretary, as already stated, for the purpose of obtaining an Order in Council to that effect, under the provisions of the Burial Act of 1853.

It is true that the dual control, which is vested by these numerous Acts in the Home Office and Local Government Board, has in some measure crippled the progress of sanitary administration both in respect to the closing of old burial-grounds and the provision of new cemeteries; but so far as official representations are concerned, the Home Office Inspector makes it a rule to consult Medical Officers of Health concerning the suitability of any proposed new site for a cemetery within their districts, so that conjoint action in this direction is as far as possible assured.

Before a site, which in other respects is deemed suitable, is selected, trial holes should be dug in various parts, and of sufficient depth, in order to ascertain the level of the underground water, and the nature of the subsoil. These trial holes should be allowed to remain open for some time, and if it is found that no water stands in any of them at a depth of 8 feet from the surface, the question of drainage becomes very much simplified, because in great measure it may be dispensed with. According to a Memorandum of the Local Government Board, drawn up by Dr. Parsons, the soil should be of an open, porous nature, and free from water or hard rock to a depth of at least 8 feet. Loam and sand, or vegetable mould, make the best soil; and clay, or gravel interspersed with loose stones or boulders, the worst. The site chosen should, as a matter of course, not be in a neighbourhood in which building is likely to take place, and by preference it should stand exposed to north or north-easterly winds. The circumstances under which there might be risk of water-pollution are pointed out, such as when graves and wells are sunk near together in a shallow, superficial, water-bearing stratum of a loosely impervious nature, resting on a bed of clay; but it does not appear that the risks to which wells are exposed from the proximity of a properly managed cemetery is, in ordinary cases, great. Indeed, according to an inquiry instituted by the State Board of Health of Massachusetts, it was found that, out of seven wells sunk in sandy and gravelly soil, varying in depth from 4 to 17 feet, and at distances from 10 to 100 feet from the nearest grave, only one was found to show undoubted signs of contamination, and this was 10 feet from the nearest grave. This tends to prove that, even in respect to old graveyards, the dangers to well-pollution, unless a well happens to be in close proximity, is comparatively

small; while, in respect to new cemeteries, all such risk would be avoided by the minimum distance of 200 feet from the nearest house being insisted on. The chief risk of pollution would arise from draining a cemetery into a brook used for drinking purposes, but this also is prohibited under heavy penalties, as has already been pointed out, by special sections of the Cemeteries Clauses Act.

As regards other conditions, it is recommended that, in new cemeteries, a strip of ground, 15 to 20 feet wide all round, should be kept free from interments on the interior of the boundary fence, which would afford space for a gravel or asphalt walk, and a fringe of trees, plants, or shrubs next the fence.

In respect to the amount of land necessary, the minimum required is usually estimated at an acre of land for every thousand of the population concerned.

To prevent overcrowding, and ensure deodorisation and natural decomposition of the bodies, the following regulations were issued by the Home Office in 1863 for grounds or cemeteries under the Burial Acts:—

> The grave spaces for persons above twelve years of age shall be at least 9 feet by 4 feet (4 square yards); under twelve years of age, 6 feet by 3 feet, or $4\frac{1}{2}$ feet by 4 feet (2 square yards). There must be at least a foot between each grave.
>
> No unwalled grave shall be reopened within fourteen years after the burial of a person above twelve years of age, or within eight years under twelve, unless to bury another member of the same family, in which case a layer of earth, not less than 1 foot thick, shall be left undisturbed above the previously buried coffin.
>
> No coffin shall be buried in any unwalled grave within 4 feet of the surface of the ground, unless it contains the body of a child under twelve years of age, when it shall not be less than 3 feet below the level.

So long as earth-burial is carried on under these

conditions, there need be no dread of either water-pollution or the propagation of disease by infected bodies after interment. It is more than probable that any micro-organisms associated with infectious disease speedily die or lose their activity so soon as natural decomposition sets in; and as regards the most infectious disease of all—viz. smallpox—it is worthy of note that no characteristic micro-organism has yet been discovered. Indeed, it may be said that this microbial scare which cremationists have endeavoured to attach to earth-burial is based solely on the oft-quoted instance that Pasteur succeeded in isolating the bacillus of anthrax from the earth, and that sheep, sojourning on a plot of ground where animals with anthrax had been buried, succumbed to the disease. Pasteur, in this instance, considered that the spores were conveyed to the surface by earth-worms, and Darwin's researches no doubt lend some considerable weight to this view. But whether this be so or not, it is well known that sheep thrive remarkably well on the luxuriant grass ground in country churchyards; and as regards risks of infection to man, it is notorious that clergymen are long livers, and that grave-diggers are not especially liable to infection, though the soil which they turn up teems with micro-organisms. It is, therefore, quite as reasonable to assume that the harmless and beneficent soil-bacteria, which are necessary for the processes of putrefaction, nitrification, and natural decay, play the part of Metschincoff's "phagocytes" (see page 428), and become destroyers of all pathogenic microbes. But apart altogether from theories, the fact remains that earth-burial, under proper conditions, or indeed under very lax conditions, has not been productive of any well-authenticated outbreaks of specific disease, and even the semblance of such an outbreak has not been discovered to emphasise the wordy warfare which has of late been

carried on between the advocates of cremation and the supporters of Mr. Seymour Haden's "earth-to-earth" system.

In the face of a sentiment which is the hereditary outcome of centuries of actual belief, there is no likelihood that earth-burial will be discontinued for generations to come, and the plea for legalising cremation, as an alternative system, would gain far more support if Mr. Seymour Haden's contentions were frankly admitted —that brick graves, vaults, leaden shells, and heavy oak coffins are all opposed to true hygienic principles, because they only retard, but do not prevent, decomposition, and always befoul natural decay.

CHAPTER XVIII

VITAL STATISTICS

VITAL statistics may be defined as the science of figures applied to the health-history of communities. They deal with the principal events or phenomena of human life,—the births, marriages, and deaths; the various diseases from which people suffer or die, together with all the influences which affect vitality. In other words, the units of which they are composed consist mainly of persons living and of persons dead, and these units are classified or grouped under certain definite characteristics, such as age, sex, place of residence, occupation, and disease. The analysis of these units or elementary facts, observed in their various relations to time and place, and dealt with according to strict numerical method, lies at the foundation of all sound inquiry, and supplies the only true criterion of sanitary progress.

SECTION I.—SOURCES OF INFORMATION

In briefly discussing this subject, for the purposes of the health officer or sanitarian, it will be convenient to refer at the outset to the two main sources from which the data which constitute vital statistics are derived, namely, the census returns, and the returns of births, marriages, and deaths, supplied by registration. As all these returns particularise the locality of every unit,

whether supplied by census or registration, the units themselves can be readily classified according to various divisions or subdivisions of the country, such as counties, towns, unions, parishes, villages, or streets, or according to urban and rural districts, as defined by the Public Health Act, 1875. For purposes of registration the country is divided into registration and sub-registration districts, which bear a more or less definite relation to counties, towns, and unions; while for sanitary purposes the particular returns, which apply to every district, however small or however large, can be obtained by every sanitary authority throughout the country from the district registrars. The management of the census, and the entire charge of the vital statistics of the United Kingdom, are entrusted to three Registrars-General, viz. one for England and Wales, one for Scotland, and one for Ireland, who publish yearly and quarterly reports for the whole country, and weekly reports for certain large towns.

1. *The Census.*—The census, or actual enumeration of the people, is effected in Great Britain every ten years. The first enumeration was made on 10th March 1801, and the last on 5th April 1891, so that the last census was the tenth enumeration of the inhabitants of this country. In order to secure accuracy of returns it is essential that the census should be taken rapidly and simultaneously; and this is effected by issuing schedules to every householder beforehand, who has to enter all the particulars concerning every one sleeping in the house on the night of the date fixed for the census. These schedules are all scrutinised and collected on the following day by the appointed enumerators, and in due course forwarded to the office of the Registrar-General, where they are tabulated and made available for statistical purposes.

It need hardly be said that the taking of a census does not consist merely of a simple enumeration of the people. Amongst other items, the schedule returns contain particulars of the name, sex, age, rank, profession or occupation, condition, relation to head of family, and birthplace of every living person who passed the night of the date of the enumeration in every house throughout the kingdom. When these returns are fully classified and analysed, they not only give the number of inhabited and uninhabited houses in every parish, town, union, or county throughout the kingdom, together with the number of inhabitants, but the population can be grouped according to age, sex, occupation, etc., thus supplying a vast storehouse of statistical information, which is of the highest value.

The following table, from the Preliminary Report of the 1891 Census, is interesting as showing the growth of the population of England and Wales, and the enormous increase in the population of London, during the present century :—

Year of Enumeration.	Population in England and Wales and in London at the Ten Enumerations.		
	England and Wales.	London.	Persons in London to 100 in England and Wales.
1801 . . .	8,892,536	958,863	10·78
1811 . . .	10,164,256	1,138,815	11·20
1821 . . .	12,000,236	1,378,947	11·49
1831 . . .	13,896,797	1,654,964	11·91
1841 . . .	15,914,148	1,948,417	12·24
1851 . . .	17,927,609	2,362,236	13·18
1861 . . .	20,066,224	2,803,989	13·97
1871 . . .	22,712,266	3,254,260	14·33
1881 . . .	25,968,286	3,814,571	14·69
1891 . . .	29,001,018	4,211,051	14·52

The aggregate population of England and Wales at the last census, including the population of London, con-

sisted of 14,050,620 males and 14,950,398 females, showing an excess of females over males of 899,778.

What is called "the natural increment" of the population is represented by the excess of births over deaths, while "the actual increment," which is always influenced to some slight extent by the balance between emigration and immigration, can of course only be determined by enumeration. Estimates of population, therefore, and especially of different localities, can never be relied upon as strictly accurate. If, for example, the rate of increase of the population had remained as it was during 1871-81, the addition to the population would have amounted to 3,729,929, whereas it was only 3,026,579, so that the estimated population at the beginning of April 1891 was 703,350 in excess of the actual population. This decline in the rate of growth was found to be due partly to a falling off in the "natural increment," and partly to an increase in the excess of emigrants over immigrants. The report also shows that the decline in the natural increase was not due to increased mortality, for the annual death-rate in 1881-91 was lower than in any earlier decennium, but to a persistent decline in the birth-rate, which was unprecedentedly low.

2. *Method of Estimating Populations.*—Having pointed out so much concerning the actual census of the people, it becomes necessary now to refer to the method of estimating populations adopted by the Registrar-General for years intervening between one census enumeration and the next. This method of calculation is based, as regards the country generally, and large populations, on the assumption that the rate of increase or decrease which prevailed between the last two census enumerations will be maintained until the next census is taken. The estimate of the population of a town or sanitary district thus obtained becomes the basis upon which the birth-

rate, death-rate, and other rates are calculated, and it need hardly be said that the nearer the estimate approaches the actual number of the population the more strictly reliable will be the statistical results. The method pursued by the Registrar-General requires the use of logarithms, and may be briefly illustrated as follows :—

If, for example, the population of any district is 100,000 at the beginning of any given year, and becomes 101,000 at the end of that year, it is evident that at the beginning of the third year it will be greater than 102,000, inasmuch as the yearly rate of increase must now be reckoned on 101,000, and not upon 100,000 as at starting. The problem, in fact, resembles one of compound interest, in which the capital by addition of the interest becomes greater each year, and consequently the amount of interest itself increases year by year, while the rate remains the same. In other words, a population increases in regular geometrical progression when the births exceed the deaths, and the ratio of the births to the deaths remains constant.

To put it algebraically, let P represent the population at the beginning of any given year, and r the net annual increase per unit of population, it will be at once evident that for every unit at the beginning of the year, there will be $1 + r$ at the end of that year or the beginning of next year, and the population has now increased to $P\ (1 + r)$. Then, assuming that the same rate of increase continues in the second year, the population at the end of that year will be obtained by the formula :—

$1 : 1 + r : : 1 + r : (1 + r)^2$, and population $= P\ (1 + r)^2$.

At the end of the third year it will be represented by $1 : 1 + r : : (1 + r)^2 : (1 + r)^3$, and population $= P(1 + r)^3$.

Further, if n be taken to represent any number of years, it will now be evident that the population at the close of the nth year, will be $P\ (1 + r)^n$

In order to apply these formulæ to any given population, the only data required are the enumerations at the two previous censuses; but as populations are estimated at the middle of the year, and the census is taken at the end of the first quarter, the quarterly increase must also be taken into account.

Let P represent the census of a population in 1881, and P′ the census of the same community in 1891, then if r = annual rate of increase per unit and $R = 1 + r$ = annual *increment* of each unit per annum, it is clear that $P\ (1 + r)^n = P\ R^n = P'$

But in this case $n = 10$, $\therefore P\ R^{10} = P'$, and $R^{10} = \frac{P'}{P}$ = rate of *decennial* increase; $R = \sqrt[10]{\frac{P'}{P}}$ = rate of *annual* increase; and $\sqrt[40]{\frac{P'}{P}}$ = rate of *quarterly* increase.

Hence to express these several formulæ in logarithms:—Log. P + 10 log. R = log. P′. Therefore log. R = $\frac{1}{10}$ (log. P′ − log. P) = log. rate of annual increase, and $\frac{1}{40}$ (log. P′ − log. P) = log. of rate of quarterly increase.

Thus the logarithm of the estimated population at the middle of 1891 is log. P′ + $\frac{1}{40}$ (log. P′ − log. P), and the estimated population of the middle, say of 1894, would be, log. P′ + $\frac{1}{40}$ (log. P′ − log. P) + 3 [$\frac{1}{10}$ (log. P′ − log. P′)].

In more general terms the rule for estimating the population of any community may be stated as follows:—From the logarithm of the most recent census, subtract the logarithm of the previous census, and then divide the logarithm so obtained by 10, and the quotient will be the logarithm of the ratio of annual increase. Add $\frac{1}{4}$ of this to the logarithm of the last census, and the sum will be the logarithm of the population at the middle of the census year. To this sum add the logarithm obtained by multiplying the logarithm of the rate of annual increase by the number of years intervening since the last census, and the sum will represent the

logarithm of the estimated population at the middle of the required year.

For example, suppose that the population of a town at the 1881 census was 240,000, and at the census in 1891 it had increased to 284,500, what will be the mean population in 1894?

(1). Log. pop. (1891), 284,500 = 5·4540823.
(2). Log. pop. (1881), 240,000 = 5·3802112.
(3). By subtraction, log. rate of decennial increase = 0·0738711.
(4). Dividing by 10, log. rate of annual increase = 0·0073871.
(5). Again dividing by 4, log. rate of quarterly increase = 0·0018468.
(6). The sum of log. pop. 1891 (1)
+ log. rate of quarterly increase (5)
+ 3 log. rate of annual increase (4) } = 5·4780904.

From the tables of logarithms the number corresponding to 5·4780904 is found to be 300,670, which would therefore be the estimate for the middle of 1894.

If it is desired to find the time in which a population will double itself, that is, in which P′ will become equal to 2P, the formulæ above given will apply. Thus—

$$P' = P\ R^n$$
$$2\ P = P\ R^n$$
$$\therefore R^n = 2$$
$$n \log. R = \log. 2$$
$$\text{and } n = \frac{\log. 2}{\log. R} = \frac{\log. 2}{\log. (1 + r)}$$

where r = the annual rate of increase per unit of population, and n = number of years in which a population will double itself.

The assumption, however, that the same rate of increase will hold good in any locality as throughout the previous decade is by no means borne out by actual figures when another census is taken. Some populations may remain stationary, others decline, while others may

increase rapidly owing to new industries springing up, or to a large influx of residents, as in popular health-resorts. Again, in the centre of large towns, there may be, and often is, an actual decrease in the population, owing to the displacement of dwellings by business premises, and the opening up of new streets, whereas the outlying suburbs may show an increase far and above that afforded by the actual excess of births over deaths. According to the census returns for 1891, the increase in the urban districts during the last decennium amounted to 15·3 per cent, while the increase among the inhabitants of the rural and suburban districts was only 3·4 per cent. Indeed, in many rural districts there has been a considerable decrease, owing to the steady migration of adults into the towns.

In small and slowly-increasing districts the following method of calculation, though fallacious for towns of any size, will give a fairly approximate estimate of the population.—Add to the population of the district as enumerated at the last census a tenth of the difference between that number and the number obtained at the previous census, for each year that has elapsed since the last census. This will give the estimated population for the end of the first quarter of any given year, but inasmuch as the death-rate is calculated on the estimated population of the district at the middle of any year, it is evident that a fourth part of the annual increment, or a fortieth part of the actual increase, of population which has taken place between the two censuses must be added to represent the increment for the additional quarter.

As regards new and rapidly-increasing districts, however, neither method of calculation will yield approximately accurate results, and in such cases it is desirable, when possible, to ascertain the number of inhabited houses for the year, which may generally be obtained

from the assessment books. A fairly correct estimate of the population can then be obtained by multiplying the average number of inhabitants per house, which can be ascertained from the last census returns, by the number of occupied houses, provided the houses which have been built since the date of the census do not vary much in size and character from those previously erected.

In the case of large towns, if the estimated population is suspected to be wide of the mark, some indication of this will be given by a marked departure from the average birth-rate or death-rate; by the number of inhabited houses as obtained from the rate-books; by returns of school attendance; or, by the condition of local industries.

It need hardly be pointed out, that as every calculation in vital statistics rests on the assumption that the population is accurately known, the trustworthiness of all calculated estimates diminishes as the interval from the last census increases. A quinquennial census, therefore, is much to be desired, and it would be advantageous in many respects to have the census taken at midsummer, and not at the close of the first quarter.

3. *Registration.*—Ever since the days of Queen Elizabeth, births, deaths, and marriages have been registered in the different parishes throughout England; but it was not till the year 1837 that the Legislature passed an Act which provided that for the future all these entries should find a place in a national register, and that as regards deaths the various causes or diseases should be certified by the medical attendant. That the important office of the Registrar-General of England, which was established by that Act, has been productive of a vast amount of benefit to the health of the nation, and indeed has largely stimulated other countries to follow in the wake of sanitary progress, there can be no doubt. The first Annual Report of the Registrar-General,

which was drawn up by the late Dr. Farr, appeared in 1839, and from the date of his appointment as Superintendent of the Statistical Department up to the date of his retirement in 1879, his was the master-mind which, by a wide yet accurate induction from statistical data, laid the foundations of public hygiene, and at the same time enlarged and established the principles of medical science.

In England and Wales there are over two thousand registrars and superintendent-registrars, whose duty it is to collect and forward to the central office at Somerset House all the certificates returned to them throughout the country. These, as already stated, apply to births, marriages, and deaths.

a. Registration of Births.—The chief data in these returns are the sex, the date of birth, the place of birth, the number of births (twins or triplets), legitimacy, and the residence of the parents. According to the Births and Deaths Registration Act, 1874, all births must be registered within 42 days of their occurrence.

b. Registration of Marriages.—These returns give the name, age, occupation, residence, and condition of husband and wife.

c. Registration of Deaths.—The principal data in these returns are the date, name, residence, age, sex, occupation, condition (whether single, married, or widowed), and the fatal disease or cause of death. Deaths must be registered within five days of their occurrence.

In the case of children the age is stated in days, weeks, or months up to two years. But of all the data the most important to the hygienist is the cause of death, which has to be certified by the medical attendant, or, in cases of inquest, by the coroner. To ensure accuracy of statistical results it is highly essential that the cause of death should be clearly diagnosed, and certified according to the nomenclature of diseases drawn up by the Royal

College of Physicians, and adopted by the Registrar-General. But it must be confessed that, apart from errors in diagnosis, which frequently occur, the cause of death is too often certified in a haphazard sort of way, and with but little regard to correct medical terminology. As a rule, however, these inaccuracies apply for the most part to causes of disease which do not come under sanitary control; and in this respect, therefore, they do not vitiate statistical results to any appreciable extent, except when the primary cause of death is not certified. For example, a case of enteric fever often succumbs to pneumonia; a case of scarlatina to nephritis; a case of measles or whooping-cough to bronchitis; a case of phthisis to diarrhœa; a case of rheumatic fever to endocarditis—and so on. Now, in all such cases it is of the utmost importance that the primary cause should be certified as well as the secondary, because the former is the cause which should be classified as the actual cause of death. Accuracy of data, uniformity of data, and completeness of data, are all of them indispensable to correct statistical analysis.

But, in addition to the registration of deaths, it has long been urged by leading sanitary reformers, that no true estimate of the vitality of the nation can be formed, unless a national system of registration of cases of sickness is also established. It is true that to a certain limited extent this has been attempted by the Local Government Board, by issuing instructions to clerks of unions to furnish weekly returns of all new cases of sickness occurring among paupers, whether in-door or out-door, to the medical officers of health of their respective districts; but the information thus supplied is often of a very incomplete kind, and, except as regards cases of fever or infectious disease, is practically of little value. Of far greater importance is it for purposes of sanitary

defence that the Infectious Diseases (Notification) Act of 1889, which has now been adopted in the great majority of sanitary districts, should be made compulsory throughout the country as it is in London, because without prompt information of early cases, preventive measures are often of little avail, and especially in districts where proper hospital accommodation has been provided.

Section II.—Classification

The data thus obtained are classified or grouped under various headings. For example, so far as the duties of the medical officer of health are concerned, the births are classified according to sex, and whether legitimate or illegitimate; while the deaths are classified according to residence, sex, ages, occupations, and diseases. In large urban districts the system of classification usually adopted is that of the Registrar-General, but for small urban or rural districts the limited tabular returns required by the Local Government Board will be sufficient. In either case, however, printed forms should be used for classification, and arranged to contain all the data for weeks, months, or quarters.

In classifying data of any kind, it is essential that the individual units should have precise and definite characters, so that every unit in a group should be strictly included in that group. Then, again, the dividing character of every group should be so distinct and clearly defined as to afford no room for doubt under which group or heading every unit should be classified. Care also should be taken that no unit should be classified so as to appear in two allied groups at the same time. Thus, we will suppose that a death has been returned as due to phthisis as the primary, and diarrhœa as the secondary, cause: it would obviously vitiate the results if the single

case were classified under the heading of diarrhœa, and also under that of phthisis.

Section III.—Statistical Results and Deductions

After the data or units have been correctly classified, it becomes possible to compare and discuss their numerical relations. For this purpose a constant numerical standard must be adopted, and in vital statistics it is the rule to state this relation or rate as so much per cent or per 1000, or some other multiple of 1000.

1. *Birth-rate.*—The birth-rate of a population or community is obtained by comparing the total number of births occurring in a year and the total population estimated, as previously shown, at the middle of the same year. It is usual to represent it as a rate per 1000 of the population living in the district, at all ages. Thus we will suppose that the estimated population of a district is 11,902, and that the number of births registered in the district during the year amounted to 384, then the birth-rate is obtained as follows:—

$$11{,}902 : 1000 :: 384 : X,$$

or annual birth-rate per 1000

$$= \frac{384 \times 1000}{11{,}902} = 32{\cdot}2.$$

The birth-rate in England and Wales in 1890 was equal to 29·7 per 1000 persons estimated as living at the middle of the year, and it has fallen continuously since 1874, when it was 36·3 per 1000. The rate of illegitimate births is generally represented as a percentage of the total number of births, or it may be represented per 1000 persons living. Taking the whole of England and Wales, and neglecting decimals, one child

out of twenty is born out of wedlock, but the rate of illegitimacy is declining.

Male births are everywhere more numerous than female, but in England and Wales the proportion of boys to girls is smaller than in any other European country, the proportion being 104 boys to 100 girls.

The high birth-rates which prevail in large urban districts are in great measure due to the fact that the marriage-rate is higher, and that women marry younger than they do in country districts; while another cause which no doubt operates to a considerable extent is the high rate of infant mortality, thus shortening the intervals of child-bearing, by the early deaths of the new-born. In fashionable towns, where large numbers of unmarried servants are employed, and where a large proportion of the residents are retired people, the birth-rate is always very low.

2. *Marriage-rate.*—This, like the birth-rate, is usually calculated at a rate of persons marrying per 1000 of the population living in the middle of the year. The average marriage-rate in England and Wales during the ten years 1871-80 was 16·1 per 1000. In 1890 the rate had fallen to 14·7.

3. *Mortality.*

(1.) *Total Annual Death-rate*—What is called the general death-rate, or total annual death-rate, of any district or community, is determined by means of a ratio between the number of deaths occurring during the year and the estimated population in the middle of the year, and, like the birth-rate, is represented as a rate of so many deaths per 1000 of the estimated population. Thus, we will suppose that the estimated population of a district amounts to 22,151, and that the number of deaths which occurred in the district during the year amounted to 335, then the total annual death-rate would be calculated as follows:—

$$22{,}151 : 1000 :: 335 : X,$$

or

$$X = \frac{335{,}000}{22{,}151} = 15 \cdot 1,$$

where X represents the total annual death-rate per 1000.

The death-rate in England and Wales in 1890 was 19·2 per 1000 persons estimated to be living at the middle of the year.

In estimating the death-rate of a large town divided into several sub-districts with different populations and different death-rates, it would be manifestly erroneous to take the average of the several death-rates as representing the total death-rate. Either the whole of the deaths occurring in the several districts must be added together and the death-rate calculated on the total population, or the calculation should be made as follows:—Let a, b, c represent the component parts of a population, and let x, y, z represent the different death-rates per unit of the population respectively:—

Then the number of deaths in $a = ax$, in $b = by$, and in $c = cz$; therefore the total number of deaths in $a + b + c = ax + by + cz$, and $\frac{ax+by+cz}{a+b+c} =$ death-rate per unit for the whole.

This may be illustrated by the following problem:—If in a town with a total population of 80,000 one district, a, with a population of 30,000, has a death-rate of 18 per 1000; another district, b, has a population of 40,000 with a death-rate of 20 per 1000; and a third district, c, has a death-rate of 10 per 1000 and a population of 10,000—what is the death-rate for the whole town? Here $\frac{ax+by+cd}{a+b+c} =$ total death-rate per unit of total population. Therefore $\frac{(30{,}000 \times \cdot 018)+(40{,}000 \times \cdot 020)+(10{,}000 \times \cdot 010)}{80{,}000} \times 1000 =$ total death-rate per 1000 of population $= \frac{540+800+100}{80} = 18 \cdot 0$. If, however, the average of the several death-rates had

been taken, the total death-rate would have been expressed as 16·0 per 1000.

It thus appears that in estimating the death-rate of a total population when the death-rates of the component parts are given, the calculation must be based on the relative proportion existing between the component parts, and it is only when those parts are equal that the mean of the several death-rates would represent the total death-rate.

In the great majority of sanitary districts the total annual death-rate does not represent the *actual* death-rate, and corrections must be made for deaths of persons not belonging to the district, which occur in hospitals, workhouses, asylums, or among visitors, and for the deaths of persons belonging to the district which occur outside the district. Take, for example, the statistics of a town of some 10,000 inhabitants in the centre of a union of some 55,000 inhabitants. The town is a separate sanitary district, but contains the workhouse for the whole union. It is evident that the death-rate for the town would be represented as larger than it really is if no correction were made for the deaths which occur in the workhouse; while, on the other hand, the death-rate of the surrounding rural district would appear less than it actually is, unless the quota of in-door pauper deaths belonging to it is added to the total number of deaths. To make these corrections the statistics of deaths occurring in these institutions, giving full particulars of age, sex, and residence, must be obtained. Further, it should be noted that if the institutions in a district are large, and receive the great majority of their inmates from other districts, the population of the institutions should be deducted from the total population before calculating the annual death-rate.

So far, then, the problem of calculating the annual death-rate of any town or district becomes a very easy

matter when the statistics are summarised for a whole year. But in respect to some large towns it is customary for the health officer to publish weekly, monthly, or quarterly reports; and as all the rates given in these reports are calculated as annual rates per 1000 of the population living in the middle of the year, the problem becomes considerably more complicated. When monthly reports are submitted, some medical officers of health calculate the annual rates by taking five weeks for the months of March, June, September, and December, and four for the other months; but this method, though convenient, is not strictly accurate, and it is much preferable to adopt the method pursued by the Registrar-General. This assumes that all the rates published, whether they relate to a year, a month, or a week, are annual rates to 1000 persons living, and represent the number of persons who would die in the year in 1000 of each population, if the proportion of deaths to population recorded in the shorter periods of a week, a month, or a quarter, were maintained throughout a whole year. Now the correct number of days in a natural year is 365·24226, and the number of weeks in a year is 52·17747. The Registrar-General, therefore, divides the estimated population of each of the large towns, whose rates are published weekly, by 52·17747, and thus obtains what may be called the weekly, population of the town, which is assumed to remain constant throughout the year. Thus, if the estimated population of a town for a given year is 267,881 persons, its weekly population for the year is

$$\frac{267{,}881}{52{\cdot}17747} = 5134.$$

Then, if the deaths in any given week amount to say 127, the total annual death-rate per 1000 would be

$$\frac{127 \times 1000}{5134} = 24{\cdot}74.$$

In the same way, to calculate the annual death-rate for any given month or quarter, the total estimated population is divided by 365·24226 to obtain what may be called the daily population for the year, and this number is used in arriving at the population for any given month or quarter, inasmuch as the length of a month varies from 28 to 31 days, and of a quarter from 90 to 92 days. To facilitate these calculations, the daily and weekly populations may be expressed in logarithms which would remain as constants during the year. Thus in the above example

log. 127,000 − log. 5134 = log. of annual death-rate.

or

$$5{\cdot}1038037 - 3{\cdot}7104559 = 1{\cdot}3933478 = 24{\cdot}74.$$

In his published quarterly returns the Registrar-General makes his death-rates for each quarter refer to the thirteen weeks corresponding most nearly with the natural quarter; and the quarterly population is obtained by multiplying the weekly population by 13.

In addition to the birth-rate and death-rate, the other rates which should be given, even in the most restricted annual reports of medical officers of health, are the death-rate from zymotic disease, and the rate of infant mortality.

(2.) *Zymotic Death-rate.*—What is called the death-rate from the seven principal zymotic diseases, or zymotic death-rate, is based on the total number of deaths occurring in a district during the year due to smallpox, measles, scarlatina, diphtheria, whooping-cough, fever (typhus, typhoid, and other or doubtful forms of continued fever), and diarrhœa. This, like the birth-rate or total annual death-rate, is calculated on the estimated population of the district, and is expressed as so many per 1000. Thus, we will suppose that in an estimated population of 22,438 the deaths from the seven principal

zymotic diseases amounted to 48 during the year; the zymotic death-rate in this instance would be:—

$$\frac{48 \times 1000}{22,438} = 2\cdot1 \text{ per } 1000.$$

According to the returns of the Registrar-General, the mean annual death-rate from the seven principal zymotic diseases in England and Wales in the three decades 1851-60, 1861-70, and 1871-80 was 3·87, 4·11, and 3·36 per 1000 respectively, while during the ten years 1881-90 it has fallen to 2·30.

The annual death-rate from any other group of diseases, or from any single disease such as fever or phthisis, is calculated in the same way as the zymotic death-rate.

(3.) *Rate of Infant Mortality.*—The rate of infant mortality, in the returns of the Registrar-General and in most health reports, is measured by the proportion of deaths of infants under one year to births registered, and is expressed as so many per 1000 births. Thus, we will suppose that the total number of deaths of children under one year of age which occurred in a given district amounted to 112 during the year, and that the births registered during the year amounted to 898, the rate of infant mortality estimated in this way will therefore be—

$$898 : 1000 :: 112 : X,$$

or

$$X = \frac{112 \times 1000}{898} = 124.$$

The annual rate of infant mortality in England and Wales for 1890 was equal to 151 per 1000 registered births, while the average rate for the ten years 1871-80 was 149 per 1000.

Most of the causes of infantile mortality are common

to every locality, but are more prevalent in large towns than in small urban or rural districts. Such as—

(*a*) *Early marriages* and weakly parents.

(*b*) *Hereditary tendencies, e.g.* syphilis, scrofula.

(*c*) *Insanitary surroundings and unfavourable social conditions, e.g.* poverty, vice, drunkenness, uncleanliness.

(*d*) *Improper feeding.*—In manufacturing towns the employment of women in mills and factories during pregnancy and shortly after childbirth has a most disastrous effect on the welfare of their infants, which are often sent out to nurse during the day, and are improperly fed or neglected. Indeed, improper feeding may be set down as the chief factor in producing infantile mortality amongst all classes, but more especially amongst the poor and ignorant. The improper substitution of farinaceous foods during the early period of infant life, and the use of uncleanly bottles for feeding with milk, contribute largely to the mortality from diarrhœa, marasmus, and convulsions.

(*e*) *Insufficient clothing and exposure.*—There is no doubt that the high mortality among infants from bronchitis and pneumonia during severe weather is largely due to want of proper clothing, and the reckless exposure to which they are subjected.

(*f*) *Infant life insurance.*—There is no doubt that this sinister form of thrift tempts to culpable neglect in the care and nursing of infants, and the fact that there is a much greater mortality among insured than among uninsured children proves that this baneful system constitutes an additional hazard to infant life.

(4.) *Death-rate at various groups of ages.*—The death-rate of children under five years of age is sometimes expressed as a percentage of the total number of deaths, which is a very fallacious method. To be of real value, it should always be expressed as a rate per 1000 of the

estimated number of children under five years living in the middle of the year. Indeed, what is called the age-distribution of populations is the only real basis on which the relative value of death-rates can be determined. Dr. Ransome has very clearly illustrated this by the following example. Suppose A and B are two towns, each with a population of 1000, and similarly circumstanced as to sanitary conditions. A has 150 children under five years of age, B has only 100 under five, which in each case die at the rate of 10 per cent per annum, while persons over five die in each town at the rate of 10 per 1000.—

Then in A, out of 150 children 15 die, and out of 850 over five 8·5 die = 23·5 per 1000 of the population. In B, out of 100 children 10 die, and out of 900 over five 9 die = 19 per 1000 of the population.

It thus appears that there is a difference of 4·5 in the death-rate per 1000, due entirely to the difference in the age-distribution of these two localities. (Newsholme's *Vital Statistics.*)

But apart from the influence of age-distribution, the mortality rate of different localities is affected to some extent by sex-distribution, because at nearly all ages the death-rate of females is lower than that of males. Hence an excess of females, as in residential localities where there is a large number of domestic servants, must tend to lower the death-rate. Generally speaking, the influence of age and sex-distribution favours a low mortality in rapidly-increasing towns, in new localities, and in manufacturing districts, while in rural districts it increases the death-rate.

The following tables, from the Supplement to the Forty-fifth Annual Report of the Registrar-General, will serve to illustrate the influence of age and sex-distribution on mortality rates more clearly:—

AGE-DISTRIBUTION OF POPULATION (PERSONS) OF ENGLAND AND WALES. (Mean of 1871-1881.)

All Ages.	Age-Periods.										
	Under 5	5–	10–	15–	20–	25–	35–	45–	55–	65–	75 and upwards.
1000	136	120	107	97	89	147	113	86	59	33	13

AVERAGE ANNUAL DEATH-RATE PER 1000 LIVING, OF MALES, FEMALES, AND BOTH SEXES, AT TWELVE GROUPS OF AGES, DURING 1871-80.

	All Ages.	Under 5 years.	5–	10–	15–	20–	25–	35–	45–	55–	65–	75 and upwards.
Males	22·61	68·14	6·67	3·69	5·23	7·32	9·30	13·74	20·05	34·76	69·57	169·08
Females	20·00	58·10	6·20	3·70	5·43	6·78	8·58	11·58	15·59	28·54	60·82	155·83
Both Sexes	21·27	63·12	6·43	3·70	5·33	7·04	8·93	12·62	17·72	31·49	64·85	161·59

From these figures it will be seen that, in comparing the general death-rates of different populations, corrections must be made for age and sex-distribution, although the former exercises the far greater influence of the two. The method adopted by the Registrar-General for making these necessary corrections may be briefly described as follows:—The mean annual death-rate for England and Wales for each sex and at each of the twelve age-periods during 1871-80 is applied to the town or registration district under consideration, with age and sex-distribution, as shown in the 1881 census. The total number of deaths thus calculated, divided by the census population and multiplied by 1000, gives the *standard death-rate*, which varies in every town or district according to the age and sex-distribution of the population. The mean annual death-rate of England and Wales during 1871-80, viz. 21·27, is then divided by this standard death-rate,

and a *factor* is obtained for each town or district, known as the *factor for correction*, by which the recorded death-rate of any year is multiplied. The result is what is called the *corrected death-rate*, which neutralises the disparity which would otherwise exist when death-rates of different populations are compared with each other, if the influence of age and sex-distribution were not taken into account. What is called the *comparative mortality figure* is obtained by dividing the corrected local death-rate by the death-rate for the whole country and multiplying by 1000, and merely signifies that the same number of persons which gave 1000 deaths in England and Wales gave so many deaths in the town in question.

This method of correction of the death-rate for age and sex-distribution is applied to the twenty-eight large towns whose rates of mortality are published weekly by the Registrar-General, and the following excerpt from the 1887 table will serve for illustration :—

Towns.	Standard Death-rate.	Factor for correction for Age and Sex-Distribution.	Recorded Death-rate.	Corrected Death-rate.	Comparative Mortality Figure.
England and Wales	—	1·000	18·78	18·78	1,000
Brighton . .	20·66	1·0296	16·88	17·38	925
Derby . . .	20·45	1·0402	17·13	17·82	949
Norwich . .	22·24	0·9565	20·44	19·55	1,041
Birmingham .	19·95	1·0663	19·72	21·03	1,120
Manchester . .	19·09	1·1143	28·67	31·95	1,701

The first step in the construction of this table is to estimate the standard death-rate, which signifies the death-rate at all ages, calculated on the hypothesis that the rate at each of twelve age-periods in each town was the same as in England and Wales during the ten years 1871-80. The mean annual death-rate for England and

Wales for each age-period during that decennium and for each sex is multiplied by the population of each sex at each period, as enumerated in the 1881 census of each of the large towns, and this divided by 1000 gives the calculated number of deaths of each sex for each age-period. In this way the total number of calculated deaths for each town is obtained, and this, multiplied by 1000 and divided by the total population as recorded in the 1881 census, gives the standard death-rate per 1000. Thus in Brighton the total population in 1881 was 107,546, while the total number of calculated deaths was 2221·34, therefore

$$\frac{2221 \cdot 34}{107{,}546} \times 1000 = 20 \cdot 66 \text{ per } 1000,$$

which is the standard rate given in the preceding table. Now as the average death-rate for the whole of England and Wales during 1871-80 was 21·27, the standard death-rate being lower for Brighton, it must be raised in the same proportion to bring it into comparison with the death-rate of England and Wales; in other words, it must be increased in the proportion of 20·66 to 21·27. But the fraction $\frac{21 \cdot 27}{20 \cdot 66} = 1 \cdot 0296$, which is the *factor for correction*, and the recorded death-rate for 1887, multiplied by this factor, gives the corrected death-rate for that year. (Newsholme's *Vital Statistics.*)

In almost all towns the factor for correction is above unity, while in rural districts, owing to the excessive proportion of children and old people as compared with towns, it is below unity.

In calculating the death-rate at various groups of ages, it is necessary to know the population at these groups, and the number of deaths occurring in each group. For the population at all ages the same rate of increase at each group of ages is assumed to continue as in the previous intercensal period.

Sex has a very important bearing upon the mortality from certain diseases, owing partly to differences in constitution, and partly to exposure to conditions favourable to the development of these diseases. For example, among females there is a higher mortality from phthisis from 5 to 25 years than there is among males, and from digestive diseases from 20 to 45 years. There is also a higher mortality among females over 10 years from scarlatina, owing probably to the greater exposure to infection. In respect to age, again, there is a still more marked relation to mortality from certain diseases applying to both sexes. For instance, the maximum mortality from smallpox, whooping-cough, and diarrhœa occurs in the first year of life; from measles in the second; from scarlet fever in the third; and from diphtheria in the fourth. Phthisis is at its minimum from the fifth to the tenth year, when it increases up to the forty-fifth year and then diminishes. Cancer mortality is insignificant in the earlier years, but increases rapidly from about the twenty-fifth year to the close of life.

(5.) *Influence of Occupation on Mortality.*—In a paper read before the Congress of Hygiene and Demography in London in 1891, Dr. Ogle has represented in tabular form the comparative mortality of numerous occupations based on the statistical returns of 1881-82-83. The age-period dealt with was from 25 to 65 years, because this period shows the influence of occupation most markedly. As clergymen were found to have the lowest mortality, the death-rate amongst this class was taken as the standard of comparison, and represented by 100. Compared with this standard the mortality amongst medical men between these ages was 202; of lawyers, 151; innkeepers, 273; brewers, 245; cutlers and scissor-makers, 235; file-makers, 300; earthenware-makers, 313; coal-miners, 160; and Cornish miners, 331. The

comparative mortality from phthisis and diseases of the respiratory organs among men working in different degrees of air impurity has already been discussed in Chapter III. (see p. 114).

(6.) *Mortality in relation to density of population.*—According to the late Dr. Farr, the mortality of districts increases with the density of their population; but density of population is a complex condition, implying a combination of many separate morbific agencies, hereditary, social, and sanitary, which can only be ascertained by analysing and comparing statistical results, and especially with regard to age-distribution. But even when due allowance is made for age-distribution, it is found that the mortality in all the crowded parts of large towns is much higher at nearly all ages, and especially during childhood, adolescence, and the productive period of life, than in the better circumstanced and more salubrious suburbs. And this excessive mortality is perhaps attributable in far greater degree to undue overcrowding than to mere aggregation of dwellings, though the two are generally associated. Thus, Dr. Russell, medical officer of Glasgow, in an address delivered to the Glasgow Philosophical Society in November 1888, has demonstrated most strikingly the connection between the size of the average house and the general death-rate. Of eight great Scotch towns, Aberdeen, which has 13·6 per cent of its population living in one room, presents the lowest death-rate, the death-rate rising *pari passu* with the diminution in size of the ordinary house, until Glasgow, with 24·7 per cent of its population living in one room, exhibited the highest death-rate. These one and two room houses are commonly "made-down houses," *i.e.*, parts of houses of larger size which are now let separately, and, in some cases, single rooms are divided by wooden partitions, and let to two separate families.

On comparing the death-rates of these various classes of the population it was found that the death-rate among those living in one or two rooms was 27·74 per 1000; among those living in houses of three and four rooms it was 19·45 per 1000; while among those living in houses of five rooms and upwards it was only 11·23 per 1000.

As regards the incidence of certain classes of diseases upon these sections of the population, Dr. Russell selected zymotic diseases, diseases of the lungs (including consumption), diseases special to children under five years of age; and deaths of children from accident and syphilitic diseases, "a small class, but one pregnant with meaning."

The results are given in the following table (see Newsholme's *Vital Statistics*):—

	One and Two-Room Houses.	Three and Four-Room Houses.	Five Rooms and upwards.
Zymotic Diseases	478	246	114
Acute Diseases of the Lungs (including Consumption) .	985	689	328
Nervous Diseases and Diseases of Nutrition in children .	480	235	91
Accidents and Syphilis in children	32	11	—
Miscellaneous Unclassified Diseases	799	764	590
All Causes	2774	1945	1123

It will be at once seen from this table how heavy is the mortality, more especially from zymotic diseases, and diseases occurring among children in the one and two-room houses compared with the mortality in the three, four, and five-room houses, and how close a relation the mortality from these largely-preventable diseases bears to the amount of indoor accommodation.

(7.) *Mortality in relation to Seasons.*—In estimating the significance of statistical results, no correct inferences can be drawn unless due attention is paid to the important

influence of weather changes. Generally speaking, it may be said that during winter there is a predisposition to diseases of the respiratory organs, and that any fall below the mean average temperature is followed by an increased sick-rate and death-rate from these diseases. During summer, on the other hand, intestinal disorders become more prevalent, and any rise above the mean average temperature will be followed by an increased sick-rate and death-rate from diarrhœa and filth diseases generally. As a rule, the mortality is highest in the first quarter of the year and lowest in the third,—the order from highest to lowest being first, fourth, second, third,—but in many districts this sequence is found to vary considerably, and indeed, it is found to vary in respect to the country generally, as the following table will show (see also chapter on Meteorology):—

Years.	Annual Death-rates per 1000 living in the Quarter ending the last day of			
	March.	June.	September.	December.
1870-79 . .	24·1	21·1	19·8	21·6
1885 . . .	21·8	19·3	16·5	18·5
1889 . . .	19·5	17·2	16·7	18·1

Apart from the influence of season, there are certain factors which appear to operate in determining cyclical changes, more especially in respect to diseases of an infectious character, and regulate to a certain extent their periodicity. One of these factors, and that probably the most potent, is the influence of an accumulation of susceptible persons in the intervals between two epidemics of the same disease. The other factors have been vaguely classed under the term "epidemic influence," which, after all, means nothing more than the propagation of disease

among susceptible persons through the agency of infection, and which may be often intensified by meteorological or telluric conditions.

It is therefore gratifying to find that measures adopted for the control of infectious diseases, and improved sanitation, are bearing good fruit, and that more accurate diagnosis and more enlightened treatment are also producing noticeable changes in the mortality rates from various diseases. This is well illustrated in the following table, abridged from the Registrar-General's Report for 1889 :—

MEAN ANNUAL DEATH-RATES PER 1000 LIVING.

	1866–70.	1871–75.	1876–80.	1881–85.	1886–89.
Smallpox	0·10	0·41	0·08	0·08	0·01
Measles	0·43	0·37	0·38	0·41	0·47
Scarlet Fever	0·96	0·76	0·68	0·43	0·24
Whooping-Cough	0·55	0·50	0·53	0·46	0·43
Diphtheria	0·13	0·12	0·12	0·16	0·16
Typhus		0·08	0·03	0·02	0·01
Enteric Fever	0·85	0·37	0·28	0·22	0·17
Simple Continued Fever		0·14	0·07	0·03	0·02
Diarrhœa	1·06	1·00	0·83	0·65	0·67
Puerperal Fever	0·06	0·09	0·06	0·09	0·077
Thrush	0·050	0·050	0·048	0·029	0·022
Alcoholism	0·035	0·038	0·042	0·048	0·051
Rheumatic Fever	0·12	0·13	0·14	0·10	0·08
Rheumatism				0·03	0·03
Cancer	0·40	0·45	0·50	0·54	0·61
Phthisis	2·45	2·22	2·04	1·82	1·598
Diabetes	0·03	0·04	0·04	0·05	0·06
Diseases of Nervous System	1·61	1·72	1·80	1·80	1·76
Convulsions	1·20	1·11	0·97	0·84	0·76
Diseases of Circulatory System	1·10	1·26	1·42	1·46	1·64
Diseases of Respiratory System	3·39	3·69	3·80	3·53	3·46
Croup	0·21	0·18	0·15	0·16	0·13
Diseases of Digestive System	1·18	1·17	1·17	1·11	1·11
Diseases of Urinary System	0·29	0·33	0·37	0·42	0·43
Diseases of Parturition	0·11	0·11	0·08	0·07	0·06
Accident and Negligence	0·68	0·67	0·63	0·58	0·53
Homicide	0·019	0·017	0·014	0·013	0·011
Suicide	0·066	0·066	0·074	0·074	0·079
Ill-defined Causes	0·21	0·18	0·14	0·11	0·093

From these statistics it will be seen that there has been a marked reduction in the mortality from smallpox, scarlet fever, fever, diarrhœa, and phthisis. There has also been a considerable decrease in the mortality from convulsions and croup, but this is no doubt attributable in some measure to better diagnosis and more accurate certification, which also account for the lessened total of "ill-defined causes." Diphtheria shows a slight increase, which may partly be accounted for by the transference of deaths under this heading which formerly were certified as croup, though there is no doubt that, during the last few years, there has been an increase in the mortality from this disease in urban districts, and this in all probability is largely due to the influence of school attendance. Measles and whooping-cough exhibit little variation, partly because they have little or no demonstrated connection with filth diseases, and because no serious attempt has been made to cope with them by hospital isolation or disinfection. Cancer shows a marked increase, and so do diseases of the urinary organs and diabetes.

(8.) *Morbidity.*—This term has been adopted to denote the amount of sickness existing in a given community, and is intended to express the sick-rate, just as the term mortality expresses the death-rate.

In the absence of any complete system of registration of cases of disease, it becomes a matter of extreme difficulty to estimate the amount of sickness which may be prevalent in any district during any stated time. Hitherto such estimates have been based mainly on the records of benefit societies, sick-clubs, army, navy, and police, and they apply solely to disabling sickness occurring amongst men between the ages of 15 and 65. From such records of sick-time, Dr. Farr, in his Supplement to the Thirty-fifth Report of the Registrar-General, estimated that to one annual death in a body of men,

two men are constantly suffering from sickness of some severity, or, in other words, that to every death there are two years of severe sickness. In the police and some friendly societies the constantly sick to every death which occurs are 2·8, while in the army at home the ratio is 4·2, the difference being due to the prevalence of enthetic disease.

According to Mr. Sutton, the actuary to the Registry of Friendly Societies, the average number of days' sickness per member while in receipt of sick-pay is very nearly $1\frac{1}{2}$ weeks per annum. On the basis of these data and Dr. Farr's estimate, it may be assumed that as in 1890 there were 564,248 deaths in England and Wales, there were 1,028,496 constant sufferers from severe sickness, and nearly two million sufferers from such illness as would require medical relief, or throw the members of Friendly Societies on their clubs. It need hardly be said that the amount of sickness represented by these figures implies an immense pecuniary loss to the State.

With regard to diseases which, as a rule, occur only once during a lifetime, such as scarlatina, smallpox, and some of the other zymotic diseases, an approximate estimate of the number of cases occurring in a district can sometimes be made from the number of deaths. Thus the mortality occurring among cases of scarlatina admitted into hospitals has been taken as a basis for calculating the number of cases in any district from the deaths registered in such district, and the ratio estimated in this way has been given as about ten cases for every death. But such estimates are comparatively valueless, because, apart from the incompleteness of the data on which they are based, the mortality will vary very much according to the severity of the epidemic. Far more reliable statistics will doubtless be obtained after an

extended experience of the registration of cases of infectious disease in towns and districts where the Infectious Diseases (Notification) Act is in force.

SECTION IV.—LONGEVITY AND LIFE-TABLES

1. The term longevity is used to embrace various statistical expressions, such as—

(1.) The mean age at death.

(2.) The probable duration of life.

(3.) The mean duration of life.

(4.) The expectation of life, or mean after-lifetime.

(1.) The *mean age at death* of a population is obtained by dividing the sum total of the ages at death by the number of deaths. It is a very fallacious indication of longevity, and affords no true test of sanitary condition, because it fluctuates very largely according to the varying proportions of young and old lives in different districts. In districts where the birth-rate is high the mean age at death will be comparatively low. The mean age at death of an entire generation alone gives accurately the mean duration of life, and this is determined by life-tables. According to Dr. Farr's life-table, which was based upon the census and mortality returns 1838-54, the mean age at death of an English generation was 40·86 years. But inasmuch as the population of England is not stationary but always rapidly increasing, the mean age at death of all who died during the years 1838-54 was 29·4 instead of 40·86. Owing to the recent decline in the death-rate in consequence of improved sanitation, the mean age at death of all who died during 1871-80 has been raised to about 32 years.

(2.) What is called the *probable duration of life*, or *vie probable*, is the term used to signify the age at which any number of children born into the world will be reduced

to one-half, so that there are equal chances of their dying before and after that age. It can only be ascertained from a life-table, and is of little value as a test of longevity. Out of a million children born the boys become reduced to one-half their number before they reach their forty-fifth year, and the girls lose half their number by the forty-seventh year.

(3.) The *mean duration of life*, or *vie moyenne*.—When a population is stationary, that is, when its age and sex-constitution do not alter, the mean duration of life is identical with the mean age at death. When the population is not stationary, or, in other words, is increasing by excess of births over deaths, by immigration, or by both these causes, the mean duration of life has the same signification as the mean after-lifetime.

(4.) The *expectation of life* at any age is the average number of years which a person at that age will live, as shown by a life-table. The expectation of life at birth is synonymous with the mean duration of life, but at any age after birth it represents the *mean after-lifetime*. As applied to communities, it is the mean lifetime of a generation of persons traced by the life-table method from birth to death, and is the only true test of the health of populations.

The mean age at death, or expectation of life after birth, in an increasing population may be approximately calculated by the following formulae:—

a. According to Dr. Farr, if X = expectation of life at birth, b = birth-rate per unit of population, and d = death-rate per unit, then $X = (\frac{1}{3} \times \frac{1}{b}) + (\frac{2}{3} \times \frac{1}{d})$.

For example, the average birth-rate during the ten years 1871-80 was 35·35 per 1000 = ·03545 per unit of population, and the death-rate was 21·4 per 1000 = ·0214 per unit, then $X = (\frac{1}{3} \times \frac{1}{\cdot03545}) + (\frac{2}{3} \times \frac{1}{\cdot0214}) = 40\cdot31$ years. This is somewhat below the actual estimate, for

according to Dr. Ogle's life-table for the corresponding period, the mean duration of life for males is 41·35 years, and for females 44·62 years.

b. In Dr. Bristowe's formula, which assumes that the birth-rate and death-rate continue uniform from year to year, that there is no immigration or emigration, and that all the inhabitants die at the same age, $X = \frac{\log. b - \log. d}{\log. (1 + r)}$ where b = birth-rate per unit, d = death-rate per unit, and r = its annual increase = $b - d$.

c. For ages between 25 and 75 the formula of Willich gives fairly approximate results. According to this, if X = expectation of life, and a = present age, then $X = \frac{2}{3}(80 - a)$. Thus, at the age of 50, the expectation of life would be $\frac{2}{3}(80 - 50) = 20$, and, according to Dr. Ogle's life-table, it is 18·93 for males, and 20·68 for females.

2. *Life-Tables.*—According to Dr. Farr, a life-table is a biometer which indicates the exact measure of the duration of life under given circumstances, and is as indispensable in gauging the influence of sanitary or insanitary conditions as the barometer or thermometer and other instruments are in physical research.

In constructing a life-table, the two essentials are the number and ages of the living, and the number and ages of the dying. The former are obtained from a census population, in which the distribution according to ages and sexes is known, and the latter from the returns of deaths grouped as regards age and sex in the same way as the census population. In order, however, to ensure as great accuracy as possible, it is advisable to take the death-returns of a whole intercensal period, and the mean population. Thus Dr. Ogle's extended Life-Table was based on the mean population of the decennium 1871-80, and the deaths during the same period.

By making the births the basis of a life-table, the

decrement in the first year will be represented by the infant mortality. Thus we will assume that in starting with a hypothetical generation of 100,000, the rate of infant mortality is 150 per 1000 births, then at the end of the first year the number will be reduced to 85,000, because that rate of infant mortality represents 15,000 deaths. In order to find the number of survivors at the close of the second year, it is necessary to use a special formula which is based upon the rate of mortality of the mean population living during the second year. Thus, we will suppose that M represents the death-rate per 1000 living at that age. Now these M deaths per 1000 living are supposed to be evenly distributed over the whole of the year, so that $\frac{1}{2}$M will occur in the first half of the year, and $\frac{1}{2}$M in the second half. Hence the 1000 persons may be regarded as decreasing from $1000 + \frac{1}{2}\text{M}$ at the beginning of the year, to $1000 - \frac{1}{2}\text{M}$ at the close of the year, and the ratio of the final to the initial population is $\frac{1000 - \frac{1}{2}\text{M}}{1000 + \frac{1}{2}\text{M}}$. Or if we take m as the death-rate per unit of the population during the second year of life, the ratio of those surviving at the close of the second year to those surviving at the close of the first year would be $\frac{1 - \frac{1}{2}m}{1 + \frac{1}{2}m}$, and this formula represents the chance which each unit of the population has of living to the end of the second year. Whichever formula is used the result will be found to be the same. Thus, we will suppose that the death-rate during the second year is 65 per 1000 living at that age. Then M = 65, and m, the mortality per unit, = ·065.

Now

$$\frac{1000 - \frac{1}{2}\text{M}}{1000 + \frac{1}{2}\text{M}} = \frac{2000 - \text{M}}{2000 + \text{M}} = \frac{2000 - 65}{2000 + 65} = \frac{1935}{2065}$$

and

$$\frac{1 - \frac{1}{2}m}{1 + \frac{1}{2}m} = \frac{2 - m}{2 + m} = \frac{2 - \cdot065}{2 + \cdot065} = \frac{1\cdot935}{2\cdot065}.$$

It is evident that these two fractions are of equal value, so that in this instance the fraction $\frac{1935}{2065} = \cdot 93704$ represents the chance which each unit of the population has of living to the close of the second year. If, then, 85,000 are alive at the beginning of the second year, this number would be reduced to 79,648 at its close, because

$$2065 : 1935 :: 85{,}000 : 79{,}648;$$

or

$$85{,}000 \times \cdot 93704 = 79{,}648.$$

Similarly, the numbers of survivors at the close of each year down to five may be calculated. After the fifth year it is usual to proceed in group-periods of five years up to twenty-five, and afterwards in decennial periods, until the whole generation becomes extinct. But the formula used is substantially the same throughout, with this difference, that given the death-rate of a group of ages, that rate is assumed to hold good for each year included in the group. Thus, let it be assumed in this instance that m_1 represents the death-rate per unit of the population living between five and ten years of age, then $\frac{2 - m_1}{2 + m_1}$ becomes the formula representing the chance of surviving to the close of each year, and therefore $(\frac{2 - m_1}{2 + m_1})^5$ will represent the probability (p) of living to the close of the tenth year. If, now, P represents the number surviving at the end of five years, the number left at the end of ten years will be $P \times (\frac{2 - m_1}{2 + m_1})^5$, and so on until the twenty-fifth year is reached. The next age period, twenty-five to thirty-five, is a decennial period, and therefore if P^1 represents the number surviving at the beginning of that period, and μ_2 the death-rate per unit for that period, the number left at the close of the thirty-fifth year will be $P^1 \times (\frac{2 - \mu_2}{2 + \mu_2})^{10}$, and so on till the whole generation becomes extinct.

It need hardly be said, in passing, that all these calculations are carried out by means of logarithm tables.

The series of figures thus obtained constitutes what is called the l column of a life-table, and represents the number born and living at each age or group of ages, or, in other words, it represents the number surviving at certain points of time, and thus renders it possible to calculate the expectation of life at any age represented in the table. A life-table for gauging sanitary condition assumes a stationary population, recruited annually by the same number of births, male and female, as are found to exist in the general population, and traces the history of a hypothetical generation through life under all the influences and circumstances which attend each year or group of years during the era under examination.

Thus, in the following table (see Newsholme's *Vital Statistics*), abridged from Dr. Farr's Life-Table No. 3, the table starts with a hypothetical generation of 1,000,000 persons, of which 511,745 are males. Col. (1) represents certain points of time, or rather of age; (2), called the m column, represents the mortality per unit at each age x; (3) represents the probability (p) which each unit of the population has of surviving to each age x; (4) is called the l column, and represents the number surviving at each age x; and (5) represents the expectation of life at any age x:—

Dr. Farr's English Life-Table (3) for Males.

(1) Age (or Past Lifetime) (x).	(2) Annual Mortality per Unit at Age x $=m_x$	(3) Probability of Living One year from each age $=p_x$	(4) Number Born and Living at each age $=l_x$	(5) Mean After-lifetime of Males of the age x.
0	·18326	·83212	511,745	39·91
5	·01369	·98640	370,358	49·71
10	·00563	·99438	353,031	47·01
15	·00519	·99482	344,290	43·18
20	·00832	·99171	333,608	39·48
25	·00920	·99084	319,442	36·12
35	·01105	·98901	288,850	29·40
45	·01554	·98458	253,708	22·76
55	·02485	·97644	209,539	16·45
65	·04698	·95410	150,754	10·82
75	·10391	·90122	75,777	6·49
85	·21966	·80208	16,877	3·73
95	·42035	·65265	833	2·17
105	—	—	4	—

Now, the expectation of life, or mean after-lifetime, at any age x is calculated by adding together the years lived through by the whole of the life-table population after that age, and dividing by the number of survivors at that age. Thus in the above table the expectation of life, say at 45, may be ascertained as follows :—Add together the figures in col. (4) (l) below 45. This sum gives the number of complete decennia lived through as 453,784. But in addition to the decennia which he completes, each unit of the population is supposed to live through a certain portion of the decennium on which he enters, and this, on the basis of the hypothesis stated at the outset, is estimated to be one-half a decennium. Therefore the 253,708 survivors at 45 are assumed to live through 253,708 half decennia, or 126,854 decennia, in addition to the 453,784 decennia which have to be shared amongst them. This makes a total of 580,638 decennia,

or 5,806,380 years, and this total, divided by the number surviving at the age of 45, gives 22·88 years as the expectation of life at that age, which, as seen from the table, is only ·12 in excess of the actual expectation of life calculated by Dr. Farr's extended life-table.

According to Dr. Farr, the expectation of life by the short-method table is nearly the same up to 15 years as by the English table; at ages from 25 to 65 the differences range from ·37 to ·53 of a year, the short method giving an excess; and after that age there is a rapid increase in the mean after-lifetime by the short-method table. (See Supplement to the Thirty-fifth Annual Report of the Registrar-General.)

By means of these short life-tables Dr. Farr was able to show that the expectation of life in rural Surrey in 1841 was 45 years, in the Metropolis 37 years, and in Liverpool only 26 years. In his three national life-tables, based on the returns of the entire kingdom, there is observable a remarkable uniformity in the expectation of life at all ages from 1838 to 1854, and, indeed, in spite of annual fluctuations, the mortality remained almost stationary up till 1871. The new English Life-Table, however, prepared by Dr. Ogle, and published in the Supplement to the Forty-fifth Annual Report of the Registrar-General, exhibits the effects which improved sanitation was already beginning to produce on the expectation of life at different ages, and more especially in the earlier periods. This is shown in the following table:—

Mean After-Lifetime (Expectation of Life at various Ages) from Life-Tables based upon English Mortality in 1838-54 (Farr) *and* 1871-80 (Ogle).

Ages.	Males.		Females.	
	1838–54.	1871–80.	1838–54.	1871–80.
0	39·91	41·35	41·85	44·62
5	49·71	50·87	50·33	53·08
10	47·05	47·60	47·67	49·76
15	43·18	43·41	43·90	45·63
20	39·48	39·40	40·29	41·66
25	36·12	35·68	37·04	37·98
35	29·40	28·64	30·59	30·90
45	22·76	22·07	24·06	24·06
55	16·45	15·95	17·43	17·33
65	10·82	10·55	11·51	11·42
75	6·49	6·34	6·93	6·87
85 and upwards . .	3·73	3·56	3·98	3·88

It will be seen from this table that the expectation of life at birth is increased nearly a year and a half in the case of males, and 2·77 years in the case of females; and that up to twenty years, or, more correctly, nineteen years among males, and forty-five years among females, it is greater under the new conditions than under the old. After these ages it is less, but, as Dr. Ogle has pointed out, the number of individuals out of equal numbers at the start who survive to live these shorter lives is so much greater than before, that the aggregate life of the whole is very considerably increased. Indeed, the extended table shows that the number of survivors up to sixty-seven years among males, and ninety-two among females, is greater in the new table than in the old; in other words, a male infant has a greater chance than formerly of living to the age of sixty-seven, and a female to the age of ninety-two. The expectation of life at all

ages is greater among females than among males, but the fact that the new life-table shows that the increase in the mean after-lifetime of females is increased up to middle age, is evidence of improved sanitation, inasmuch as they live more at home, and are not subject to the accidents and wear and tear of life to which males are exposed. The influence of healthier surroundings, however, is even much more conclusively attested by the greatly increased expectation of life in infancy and childhood, and this saving of life in both sexes extends to an age which embraces the most productive periods.

For further information with regard to the construction and value of life-tables, see Farr's *Vital Statistics*, edited by Noel Humphreys, and Newsholme's *Vital Statistics.*

SECTION IV.—STATISTICAL FALLACIES.

In previous parts of this chapter various instances have been illustrated in which errors as regards statistical results are likely to creep in, *e.g.*—

(1.) In estimating the population of a town or district;

(2.) In tabulating death-returns;

(3.) In drawing conclusions from death-rates for short periods, or from death-rates of small districts;

(4.) In taking the average of the death-rates of several districts of a town or combined district as representing the general death-rate of the whole town or district;

(5.) In excluding the deaths occurring in large public institutions whose inmates do not belong to the district, while including the population of such institutions;

(6.) In estimating the infant or child mortality as a percentage of the total deaths; and,

(7.) In drawing conclusions in respect to birth-rates

and death-rates without taking into consideration the age and sex-distribution of the population.

It has already been pointed out that, in tabulating statistics and drawing inferences from them, it is essential that the facts or units should be strictly accurate, and in order to be comparable they should belong to the same category. The dividing character between each group must be precise and definite, so that the characteristics on which any group is formed should be common to each unit included in that group, and should leave no room for doubt under which group or heading every unit should be classified.

Statistics, though generally arranged in tabular form, are often represented graphically. If a square or rectangular space is divided by vertical and horizontal lines into a number of small squares drawn to scale, every one of these squares may be made to represent a group of facts or events in relation to time or other condition, and a line drawn through the intersection of these relational lines will often represent with greater clearness the exact relations which these facts or events bear to such conditions than if they were represented in tabular form.

When facts are represented by figures or numerical values, what is called the *arithmetical mean* or simple average is obtained by dividing the sum of these values by the number of facts, and the more numerous the facts, the more trustworthy become the average and proportional results.

This was well shown by the late Dr. Guy in his extended inquiry into the average age at death of members of the aristocracy who had attained the age of twenty-one years and upwards. The number of cases inquired into amounted to several hundreds, and Dr. Guy arranged his facts first into groups of 25 each; then two successive groups of 25 were formed into 50,

the groups of 50 into 100, and so on until the last totals were obtained :—

Number of Facts.	Average Age at Death. Max.	Min.	Range.
25	69·40	50·64	18·76
50	66·44	55·20	11·24
100	63·70	56·85	6·85
200	62·38	57·61	4·77
400	61·10	58·24	2·86
800	60·84	59·67	1·27
1000	60·25		

If 60 be assumed to be the true average of life among the members of the aristocracy who have attained their twenty-first year, and decimals be discarded, the second table will represent the extreme error which would have been committed by relying on 25, 50, 100, etc., facts respectively :—

Number of Facts.	Error in Excess or Defect.
25	$9\frac{1}{2}$
50	$6\frac{1}{2}$
100	$3\frac{1}{2}$
200	$2\frac{1}{2}$
400	$1\frac{1}{2}$
800	$0\frac{1}{2}$

This is an instance of eliminating error by the test of *successive means*, and it clearly illustrates how, as the number of facts accumulate, the successive averages approach to the mean average of the whole. It is, however, always possible that the average of a small number of facts may give a close approximation to the average of a long series, but such an average requires further confirmation. Whether the series be long or short, it should always be remembered that the results can never be applied to a single case. It is also an axiom in statistics that the less the difference between the average and the figures of a series, the greater is its value.

Another criterion in the estimation of the value of a series is the divergence of the individual terms of the series from its mean. What is called the *mean error* is obtained as follows :—First find the mean of the series, then find the mean of all the observations or facts above the mean, and subtract the mean from it. This gives the mean error in excess. Secondly, find the mean of all the series below the mean. This gives the mean error in deficiency. Add together the mean error in excess and the mean error in deficiency, and the mean or average of these is what is called the *mean error*. The greater the mean error the greater is the need for an extended series of facts or observations on which to base reliable conclusions.

What is called the *probable error* is obtained by multiplying the mean error by ·6745, or $\frac{2}{3}$ nearly, and is useful in showing that the smaller the latitude of error the more trustworthy is the series from which the mean or average is drawn. It is also useful in comparing the value of two or more similar groups, the relative values being inversely as the squares of the probable errors of each. Thus, if in two similar groups A and B, A has a probable error of 8 per cent, and B of 4 per cent, the squares of the probable errors will be respectively 64 and 16, or the group B will have a value four times greater than group A. Finally, it has to be noted that the value of a series of observations increases as the *square root* of the number. Thus a group of 9 observations is to a group of 100 as $\sqrt{9}$ to $\sqrt{100}$, or as 3 to 10.

The degree or extent to which proportional results from large or small numbers of observations deviate from the truth may also be determined by *Poisson's Formula*.

Thus, let $M =$ total number of cases or units in the series, $m =$ number of cases in one group, and $n =$ number

of cases in the other group. Then $m+n=M$, and $\frac{m}{M}$ and $\frac{n}{M}$ are the proportions of each of these two series to the whole.

But these proportions will vary within certain limits on subsequent occasions, with another series of similar cases, and the extent of the variation will be limited by $\frac{m}{M}+2\sqrt{\frac{2mn}{M^3}}$ and $\frac{m}{M}-2\sqrt{\frac{2mn}{M^3}}$ as regards the m group, and the same will hold good with regard to the n group. It is evident that the larger the number of M, the less will be the value of $2\sqrt{\frac{2mn}{M^3}}$, and the less the limits of error in $\frac{m}{M}$ or $\frac{n}{M}$. Thus, let it be assumed that out of 100 cases of fever, 30 die and 70 recover; how far will this ratio apply to other series of cases of the same fever? By Poisson's formula the error in this instance will be ·129 to unity, so that the range of possible recoveries out of 100,000 cases on this limited basis would be

$$70{,}000+12{,}900=82{,}900,$$

and

$$70{,}000-12{,}900=57{,}100.$$

If, however, 1000 cases are taken, out of which 700 recover, the error will be only ·04 to unity, and the range of recoveries, out of 100,000 cases, will lie between

$$70{,}000+4000=74{,}000,$$

and

$$70{,}000-4000=66{,}000.$$

With 10,000 cases observed the range of recoveries would lie between 71,290 and 68,710, while with 100,000 cases it would lie between 70,400 and 69,600, which approaches more closely to certainty. It is thus seen that by increasing the number of observations from 100 to 10,000 the accuracy is increased tenfold, because in the former instance the range of possible recoveries out

of 10,000 cases is 25,800, and in the latter only 2580. In other words, the degree of accuracy increases as the square root of the number of observations. (See De Chaumont's *State Medicine.*)

CHAPTER XIX

SANITARY LAW AND OFFICIAL DUTIES

By clauses 189-191 of the Public Health Act, 1875, it is enacted that it shall be the duty of every Sanitary Authority, throughout England and Wales, to appoint one or more legally qualified medical officers of health, and one or more inspectors of nuisances for the efficient execution of the purposes of the Sanitary Acts. Two or more sanitary authorities may appoint the same medical officer of health or inspector of nuisances, and section 286 of the Public Health Act empowers the Local Government Board to combine districts by Provisional Order for the purposes of appointing a medical officer of health. Section 17 of the Local Government Act, 1888, authorises County Councils to appoint medical officers of health, who may be prohibited from holding any other appointment, or engaging in private practice. Section 18 of the same Act requires that every medical officer of health appointed after 1st January 1892, for any district having at the last census 50,000 inhabitants or more, shall be the holder of a Public Health diploma, and be registered as such under Section 21 of the Medical Act, 1866; or shall have held, during three consecutive years prior to 1892, the appointment of medical officer of health of a district containing at least 20,000 inhabitants at the last census; or shall have been

for three years a medical officer of the Local Government Board.

In respect to all officers, half of whose salaries is repaid by County Councils to their Sanitary Authorities, the Local Government Board possesses the same powers with regard to appointment, salary, and tenure of office, as it exercises in the case of poor law officers. Although a Sanitary Authority can suspend an officer appointed under these conditions, it cannot dismiss him without the sanction of the Local Government Board, and it must forthwith report any suspension to the Board. If, however, a Sanitary Authority desires to make any change in the duties or salary of an officer, or any change is made in the extent of the district, and he declines to acquiesce therein, they can, but only with the consent of the Local Government Board, give him six months' notice to terminate his appointment. Every medical officer of health, who holds his appointment subject to the approval of the Local Government Board, is bound to forward copies of annual and special reports to the Board, and also to the County Council or Councils in which his district is situated, and in the event of his failing to do so, the Sanitary Authority may be refused repayment of half his salary, and the sum, on the certificate of the Local Government Board, shall be forfeited to the Crown. If no part of his salary is intended to be payable by a County Council, his duties are nevertheless the same as those prescribed for all health officers appointed with the approval of the Local Government Board, and he is further obliged to report his appointment within seven days to the Board.

Under the Public Health (London) Act, which came into force on 1st January 1892, metropolitan medical officers of health can only be dismissed with the sanction of the Local Government Board, and they must reside in, or within a mile of, their districts.

According to Article 18 of the Local Government Board's Order of March 1891, the following are the duties prescribed for every medical officer of health, in respect to the district or districts for which he is appointed :—

1. He shall inform himself, as far as practicable, respecting all influences affecting or threatening to affect injuriously the public health within the district.

2. He shall inquire into and ascertain by such means as are at his disposal the causes, origin, and distribution of diseases within the district, and ascertain to what extent the same have depended on conditions capable of removal or mitigation.

3. He shall, by inspection of the district, both systematically at certain periods, and at intervals as occasion may require, keep himself informed of the conditions injurious to health existing therein.

4. He shall be prepared to advise the sanitary authority on all matters affecting the health of the district, and on all sanitary points involved in the action of the sanitary authority ; and in cases requiring it, he shall certify, for the guidance of the sanitary authority or of the justices, as to any matter in respect of which the certificate of a medical officer of health or a medical practitioner is required as the basis or in aid of sanitary action.

5. He shall advise the sanitary authority on any question relating to health involved in the framing and subsequent working of such bye-laws and regulations as they may have power to make, and as to the adoption by the sanitary authority of the Infectious Disease (Prevention) Act, 1890, or of any section or sections of such Act.

6. On receiving information of the outbreak of any contagious, infectious, or epidemic disease of a dangerous character within the district, he shall visit without delay the spot where the outbreak has occurred, and inquire into the causes and circumstances of such outbreak, and in case he is not satisfied that all due precautions are being taken, he shall advise the persons competent to act as to the measures which may appear to him to be required to prevent the extension of the disease, and take such measures for the prevention of disease as he is legally authorised to take under any statute in force in the district, or by any resolution of the sanitary authority.

7. Subject to the instructions of the sanitary authority, he shall

direct or superintend the work of the inspector of nuisances in the way and to the extent that the sanitary authority shall approve, and on receiving information from the inspector of nuisances that his intervention is required in consequence of the existence of any nuisance injurious to health, or of any overcrowding in a house, he shall, as early as practicable, take such steps as he is legally authorised to take under any statute in force in the district, or by any resolution of the sanitary authority, as the circumstances of the case may justify and require.

8. In any case in which it may appear to him to be necessary or advisable, or in which he shall be so directed by the sanitary authority, he shall himself inspect and examine any animal, carcase, meat, poultry, game, flesh, fish, fruit, vegetables, corn, bread, flour, or milk, and any other article to which the provisions of the Public Health Act, 1875, in this behalf shall apply, exposed for sale, or deposited for the purpose of sale or of preparation for sale, and intended for the food of man, which is deemed to be diseased, or unsound, or unwholesome, or unfit for the food of man; and if he finds that such animal or article is diseased, or unsound, or unwholesome, or unfit for the food of man, he shall give such directions as may be necessary for causing the same to be dealt with by a justice according to the provisions of the statutes applicable to the case.

9. He shall perform all the duties imposed upon him by any bye-laws and regulations of the sanitary authority, duly confirmed where confirmation is legally required, in respect of any matter affecting the public health, and touching which they are authorised to frame bye-laws and regulations.

10. He shall inquire into any offensive process of trade carried on within the district, and report on the appropriate means for the prevention of any nuisance or injury to health therefrom.

11. He shall attend at the office of the sanitary authority or at some other appointed place, at such stated times as they may direct.

12. He shall from time to time report, in writing, to the sanitary authority his proceedings, and the measures which may require to be adopted for the improvement or protection of the public health in the district. He shall in like manner report with respect to the sickness and mortality within the district, so far as he has been enabled to ascertain the same.

13. He shall keep a book or books, to be provided by the sanitary authority, in which he shall make an entry of his visits, and notes of his observations and instructions thereon, and also the date and nature of applications made to him, the date and result of

the action taken thereon, and of any action taken on previous reports ; and shall produce such book or books, whenever required, to the sanitary authority.

14. He shall also make an annual report to the sanitary authority, up to the end of December in each year, comprising a summary of the action taken, or which he has advised the sanitary authority to take, during the year for preventing the spread of disease, and an account of the sanitary state of his district generally at the end of the year. The report shall also contain an account of the inquiries which he has made as to conditions injurious to health existing in the district, and of the proceedings in which he has taken part or advised under any statute, so far as such proceedings relate to those conditions ; and also an account of the supervision exercised by him, or on his advice, for sanitary purposes over places and houses that the sanitary authority have power to regulate, with the nature and results of any proceedings which may have been so required and taken in respect of the same during the year. The report shall also record the action taken by him, or on his advice, during the year, in regard to offensive trades, to dairies, cowsheds, and milk-shops, and to factories and workshops. The report shall also contain tabular statements (on Forms to be supplied by Us, or to the like effect) of the sickness and mortality within the district, classified according to diseases, ages, and localities.

Provided that, if the medical officer of health shall cease to hold office before the thirty-first day of December in any year, he shall make the like report for so much of the year as shall have expired when he ceases to hold office.

15. He shall give immediate information to Us of any outbreak of dangerous epidemic disease within the district, and shall transmit to Us a copy of each annual report and of any special report. He shall make a special report to Us of the grounds of any advice which he may give to the sanitary authority with a view to their requiring the closure of any school or schools, in pursuance of the code of regulations approved by the education department, and for the time being in force.

16. At the same time that he gives information to Us of an outbreak of infectious disease, or transmits to Us a copy of his annual report, or of any special report, he shall give the like information or transmit a copy of such report to the County Council or County Councils of the county or counties within which his district may be situated.

17. In matters not specifically provided for in this order, he

shall observe and execute any instructions issued by Us, and the lawful orders and directions of the sanitary authority applicable to his office.

18. Whenever we shall make regulations for all or any of the purposes specified in section 134 of the Public Health Act, 1875, and shall declare the regulations so made to be in force within any area comprising the whole or any part of the district, he shall observe such regulations, so far as the same relate to or concern his office.

For the efficient and conscientious discharge of these duties, it is evident that a medical officer of health must make himself thoroughly acquainted with the fundamental principles of public and practical hygiene, with the general and local circumstances which may affect the health of the population in his district, and with the various clauses of the Public Health and other Acts which more immediately concern his office. So much is left to his discretionary power in advising the Sanitary Authority, and in certifying as to what is or is not injurious to the public health, that he cannot but feel the grave responsibility which will devolve upon him, if through ignorance or neglect on the one hand, or through mistaken zeal and want of tact on the other, he fails to carry out his duties honestly, judiciously, and efficiently.

As there is no doubt that considerable difficulty will be experienced at the outset by most newly appointed health officers in regard to the mode in which their duties should be carried out, the various suggestions and practical details summarised under the following sections, may, it is hoped, prove alike serviceable and reliable :—

Section I.—Natural Conditions affecting the Health of the Population contained in the District.

These comprise the geological and topographical characteristics of the district, the water-supply, and the climate.

1. *Geological Conditions.*—Official information as regards these may be obtained from the geological maps of the Ordnance Survey and the special sections published by the Surveyor-General; while fuller details could be readily collected from local sources. In most districts there will generally be found some one who has made the geology of the locality a special study.

2. *Topographical Conditions.*—These relate to the situation of the various parts of the town or district, whether low-lying, elevated, or sloping. A good map showing the boundaries of the district, and its subdivisions, whether into parishes, hamlets, etc., is essential. Maps of towns should show the course of main sewers and water-mains, and also the divisions of the town into wards or sub-districts. Such maps are exceedingly useful because they can be utilised as spot maps to illustrate the distribution of disease, or the incidence of mortality.

3. *Water-supply.*—The quantity and quality of the obtainable water-supply in a district will depend very much on the two previous sets of conditions. So also will the nature of the subsoil and the facilities for drainage and sewerage. All this, however, has been fully explained in previous parts of this work.—(See Chapters VII., X., and XII.)

4. *Climate.*—Under this heading are comprised the meteorological conditions of the district, such as the daily temperature, and rainfall, the force and direction of winds,

the barometric pressure, the degree of humidity, and the amount of ozone. In most large towns these observations are carefully recorded, and where this is the case, the health officer should endeavour to obtain, through the Sanitary Authority, the record of the observations weekly. In districts where no such observations are made, it will be no part of his duty to supply this information, but at the same time it is necessary that he should take cognisance of meteorological fluctuations, because they constitute very important factors of health or disease in every district. (See Chapter VI.)

Section II.—Artificial Conditions affecting the Health of the Population contained in the district; such as—

1. *Habitations of the People.*—So far as possible the sanitary condition of every house in the district should be inquired into. Of course the health officer himself could not undertake such a laborious inquiry, but in towns it could be easily and efficiently carried out by the temporary appointment of competent persons, to assist the sanitary inspectors if necessary, who would be paid by the Sanitary Authority and directed by the health officer; while in small urban or rural districts it can be carried out by the sanitary inspector without such assistance.

In carrying out a systematic inquiry of this description in rural districts, it is advisable that the inspector should complete the survey of one or more parishes or villages before submitting the details to the medical officer of health, who would then appoint a day or days for going over the survey with the inspector. During the inspection he should satisfy himself as to the accuracy

of the returns, advise with regard to particular defects, and in this way make himself fully acquainted with the sanitary condition of every part of his district in detail. The tabulated forms to be used for such a survey will vary slightly according as the district is urban or rural, and the several columns may be arranged under the following headings. Number; date of inspection; situation and description of premises; names of occupier and owner; number of sleeping rooms, and inmates; nature, situation, and condition of closet-accommodation; nature of water-supply; defects in drainage, ventilation, or general condition of premises; existence of any special source of actual or possible nuisance; additional observations. All houses which are deemed to be unfit for human occupation, or which though unoccupied appear to be in a dangerous condition, should be carefully noted for the inspection of the medical officer of health, who is bound to report them under the Housing of the Working Classes Act, 1890. With very rare exceptions, the inspector will meet with no opposition in carrying out the survey, nor the medical officer of health in obtaining any information with regard to any points which he may consider desirable. Further particulars with regard to the sanitary condition of premises, overcrowding, nuisances generally, and how to draw up reports, will be given in Section IV. (See also Chapter XIII.)

2. *Water-Supply.*—In districts where the water-supply is public, the medical officer of health should make himself acquainted with the quality of the water, amount per head, and the risks of pollution, both as regards the source of supply and the mode of distribution. The nature of the supply, whether constant or intermittent, the relation between mains and closets; the situation and condition of cisterns; the separation of cisterns for domestic supply from those supplying closets: the situa-

tion of overflow pipes, and the like, are all points which should receive careful attention. In rural districts, the sufficiency of the water-supply, as well as its quality, the situation of wells, and the risks of pollution, should all be duly noted, and samples of suspicious well-water should be examined. In villages where the water-supply is insufficient, it will become a question for the medical officer of health to advise generally as to how this want may best be remedied, whether by providing one or more public wells, by introducing a public supply, by compelling neighbouring owners of property to unite in providing a sufficient supply under the Public Health (Water) Act, by storage of the rainfall, or by carting water into the village to meet special emergencies, leaving of course all practical details to be dealt with by the sanitary engineer or inspector. (Chapters VII. and VIII.)

3. *Drainage, Sewerage, Scavenging, etc.*—In towns full information with regard to these conditions will be obtained from the borough engineer or town surveyor. Special attention should be given to the ventilation and flushing of sewers, and the condition of house-drains as regards ventilation, flushing, freedom from smell, and construction; while the ventilation of water-closets, soil-pipes, and, as far as possible, the severance of all direct communication of house-drains with sewers, are additional points of importance which should not escape notice. The efficiency of the scavenging arrangements should also be carefully inquired into. In country districts it will devolve upon the medical officer of health to report as to whether the drainage of particular villages is satisfactory, and to recommend or not, as he may think fit, as to whether a competent engineer should be called in to survey and prepare plans. In certain cases, too, he will have to inquire and decide as to whether public

scavenging has not become necessary to ensure adequate local cleanliness. (See Chapters X., XI., and XIII.)

4. *Factories, Workshops, Bake-houses, Public Institutions, Slaughter-houses, etc.*—These should be examined with reference to overcrowding, air-impurities, and the production of nuisances generally. (See Chapter III. and Section IV. of the present Chapter.) In country districts special attention should be given to the sanitary condition of village-schools, whether public or private, and also to the sanitary condition of graveyards.

Section III.—Vital Statistics.

In addition to obtaining a full knowledge of the natural and artificial conditions which affect the health of the population, the medical officer of health should also make himself thoroughly acquainted with the vital statistics and health history of his district. By referring to the more recent quarterly and annual reports of the Registrar-General, the abstracts of the Boards of Guardians, and the reports which have already appeared with regard to the health of the district, he will obtain all the statistical data representing its vital history for the past few years, as indicated by the number of the population, its rate of increase, the birth-rate, the marriage-rate, the rate of mortality, the prevalency of epidemic or other specially fatal diseases, the death-rate at different ages, the amount of pauper sickness, etc. From the last census returns, again, he will obtain much useful information as regards the areas, houses, and population, and the ages, civil condition, and occupation of the people.

The district-registrars throughout the country are instructed by the Registrar-General to forward the returns of births and deaths to medical officers of health, and

are allowed 2d. per entry for remuneration, which the Sanitary Authority is empowered by the Local Government to pay. The Sanitary Authority also supplies the blank forms, and defrays the expense of postage. Except as regards deaths from fever or other infectious disease, a return of which should be forwarded immediately, the usual returns of the registrar should be forwarded to the medical officer of health at the close of every week. Blank forms may be obtained from Messrs. Knight and Co., publishers, Fleet Street, London; Messrs. Shaw and Sons, Fetter Lane, London; Messrs. Farrant and Frost, Merthyr-Tydfil, and other publishers, or they may be printed by order of the Sanitary Authority, according to a form drawn up by the medical officer of health. (See Appendix.)

If the district is a large urban one, the deaths may be classified according to sub-districts or streets; and if it be a large rural one, they may be classified according to sub-districts or parishes. In large urban districts the classification should be that used by the Registrar-General, or the classification drawn up by the Society of Medical Officers of Health, but in small urban or rural districts it is by no means necessary to compile elaborate tables, and the classification which is required in the official returns to the Local Government Board, will answer all practical purposes. For the sake of comparison it is much to be regretted that some uniform system of classification is not enforced in all districts, a simple system for rural and small urban districts, and a more elaborate system for urban districts containing say 25,000 inhabitants and upwards. In many districts, too, there is some chance of confusion arising from the fact that the registration sub-districts are frequently not conterminous with the several sanitary districts, inasmuch as small urban districts generally form part of a registra-

tion sub-district, the other part being included in a neighbouring rural sanitary district. Deaths of non-residents should be distinguished in the returns, and returns should also be obtained of deaths of persons belonging to the district which occur in institutions outside the district. (See previous Chapter.)

By an order of the Local Government Board, dated February 1879, all district and workhouse medical officers, appointed after 28th February of that year, are required to furnish the medical officer of health with returns of pauper sickness and deaths, and to notify cases of infectious disease. In districts where the Infectious Diseases (Notification) Act is not in force, these returns supply useful and timely information, but where the Act is in force, they are not of much value. Cases of dangerous infectious disease, occurring in canal boats or in common lodging-houses, must be reported to the medical officer of health, whether the Notification Act is in force or not, and Sanitary Authorities are empowered to make bye-laws requiring notification of such diseases in tenement lodging-houses, vans, and tents.

All cases of dangerous infectious disease which are notified or come under the knowledge of the medical officer of health, should be tabulated according to streets, sub-districts, or parishes, in the same way as the deaths, while cases removed to hospital must be classified separately.

Two forms, A and B, which are issued by the Local Government Board to Sanitary Authorities, must be filled up by the medical officer of health, and appended to his annual report. Form A is intended for tabulation of the deaths, and form B for tabulation of infectious cases. (See Appendix.)

SECTION IV.—SANITARY LAW AND SANITARY ADMINISTRATION.

As the medical officer of health must "be prepared to advise the Sanitary Authority on all matters affecting the health of the district, and on all sanitary points involved in the action of the Sanitary Authority," it is necessary that he should make himself thoroughly acquainted with the sanitary clauses of the Public Health Act of 1875, and of other sanitary Acts, or portions of them, which more immediately concern his office. He must also have a thorough knowledge of any bye-laws affecting sanitary conditions which may be in force in his district, and be prepared to "advise the Authority on any question relating to health involved in the framing of such bye-laws and regulations as they have power to adopt." The works which he will find useful to consult are Glen's or Lumley's *Public Health Acts*, Macmorrans's *Supplement to Lumley's Acts*, Glen's *Sanitary Orders*, the *Model Bye-Laws of the Local Government Board*, published by Eyre and Spottiswoode, and the *Annotated Bye-Laws*, published by Knight and Co.

In briefly summarising the numerous clauses or sections of these various Acts, which more especially affect the duties of the medical officer of health and sanitary inspector, it is necessary to premise that except where specially mentioned the summary applies only to Local Authorities in England and Wales outside the Metropolis; that when any clauses or sections of the acts or bye-laws apply solely to Urban Authorities it will be so stated; and that Urban Sanitary Authorities include City or Town Councils, Local Boards, and Improvement Commissioners. Any part of a Poor Law Union, which

is not included in an Urban District, is defined as a Rural Sanitary District, and the Guardians representing that part of the Union constitute the Rural Sanitary Authority. What are called Port Sanitary Authorities, are so constituted by Provisional Order of the Local Government Board.

I.—PUBLIC HEALTH ACT, 1875

Before proceeding to summarise the various sections of this Act which are of special interest to sanitary officials, it will be advisable to quote a few of the more important definitions which appear in the preamble to the Act. These are selected as follows:—

(1) "Lands" and "Premises" include messuages, buildings, lands, easements, and hereditaments of any tenure:

(2) "Owner" means the person for the time being receiving the rackrent of the lands or premises in connexion with which the word is used, whether on his own account or as agent or trustee for any other person, or who would so receive the same if such lands or premises were let at a rackrent:

(3) "House" includes schools, also factories and other buildings in which more than twenty persons are employed at one time:

(4) "Drain" means any drain of and used for the drainage of one building only, or premises within the same curtilage, and made merely for the purpose of communicating therefrom with a cesspool or other like receptacle for drainage, or with a sewer into which the drainage of two or more buildings or premises occupied by different persons is conveyed:

(5) "Sewer" includes sewers and drains of every description, except drains to which the word "drain" interpreted as aforesaid applies, and except drains vested in or under the control of any authority having the management of roads and not being a local authority under this Act:—

1. *Sewerage.*—All sewers, except certain private sewers, are by Section 13 of the Act vested in the local authority of the district. Section 14 empowers local authorities to purchase or construct sewers; while Section 15 renders it incumbent on them to keep all sewers belonging to them in proper repair, and to construct such sewers as may be necessary for effectually draining their districts.

Neglect of these duties is made a default by Section 299 of the Act. Section 17 enjoins that all sewage must be purified before being discharged into streams. Under Section 19 all sewers must be constructed, ventilated, and kept so as not to be a nuisance or injurious to health; and powers are given by Section 27 for the treatment and disposal of sewage. Further powers, in respect to the protection of sewers, are conferred by the Public Health (Amendment) Act, 1890 (see *post*).

2. *House-drainage.*—Sections 21-25 empower local authorities to enforce the drainage of any house which is without a sufficient drain or drains, and to prescribe the materials, size, level, and fall. If the site of the house is within 100 feet of any sewer belonging to the authority, the drain must be made to discharge into such sewer; but if the site is beyond this statutory distance, then it must discharge into a covered cesspool, but not under a house, and in such position as the authority may direct. Failing compliance with due notice the authority may carry out the work, and recover the expenses incurred. Owners and occupiers within a district are empowered to drain into the sewers of the local authority. In an *urban* district, or any district vested with *urban* powers, no new house, nor any house which has been re-built, can be occupied, unless it is drained to the satisfaction of the authority.

3. *Water-closets, privies, etc.*—Section 35 renders it unlawful to erect or rebuild any house without a sufficient water-closet, earth-closet, or privy, and an ash-pit (ash-pit midden), furnished with proper doors and coverings; while Section 36 empowers a local authority, on the report of their surveyor or inspector of nuisances, to enforce the provision of the same for any existing house, and the authority may require a separate closet for each house, if in their opinion it is deemed necessary. Failing compliance with due notice, the authority may carry out the work required to be done, and recover from the owner the expenses incurred. Under Section 37, earth-closets may be constructed instead of water-closets with the approval of the local authority, and the authority may undertake or contract to supply dry earth or other deodorising substance for such closets. Section 38 empowers local authorities to enforce adequate and separate closet accommodation for the use of both sexes employed in factories; while Section 39 empowers *urban* authorities to provide public closets, urinals, and other similar conveniences for the accommodation of the public.

Section 40 enjoins that every local authority "shall provide that all drains, water-closets, earth-closets, privies, ashpits, and cesspools, within their district, be constructed and kept so as not to be a nuisance or injurious to health." If a local authority neglects

this important duty, they may be declared a defaulting authority under Section 299.

Section 41 enacts that if on written complaint, any drain, closet, ashpit, or cesspool, is declared to be a nuisance, or injurious to health, the local authority may empower their surveyor or inspector to enter the premises after giving twenty-four hours' notice, except in cases of emergency, and open the ground, in order to make due examination. If no defects are found, the authority must close the ground and make good any damage ; but if any defects are discovered the authority must forthwith serve notice on the owner or occupier, and failing compliance, they may themselves execute such works as they may deem necessary, and recover the expenses incurred from the owner.

4. *Scavenging and Cleansing.*—Under Section 42 every local locality authority may, and when required by the Local Government Board, shall themselves undertake or contract for the removal of house refuse from premises, and the cleansing of earth-closets, privies, ashpits, and cesspools, either for the whole or any part of their district. Moreover, where the scavenging is undertaken by the authority, any occupier of premises may claim a penalty from the authority if they neglect, after written notice, to attend to the proper scavenging of his premises within seven days (Section 43). Section 44 empowers them to make bye-laws (see p. 685).

5. *Cleansing of Houses and Abatement of certain Nuisances.*—Section 46 empowers local authorities to order the cleansing and whitewashing of filthy houses, and the cleansing and purifying of infected houses, on the certificate of the medical officer of health or of any two medical practitioners. Section 47 applies only to *urban* authorities, and renders it unlawful to keep swine in any dwelling, so as to be a nuisance to any person, or to suffer any waste or stagnant water to remain within any dwelling-house for twenty-four hours after written notice from the authority, or to allow the contents of any water-closet, privy, or cesspool to overflow or soak therefrom. In case of non-compliance with notice the occupier renders himself liable to a penalty, and the *urban* authority may themselves abate the nuisance and recover the expenses incurred from the occupier.

6. *Offensive Ditches and removal of collections of offensive matter.*—Section 48 empowers local authorities to obtain an order from the justices for the cleansing of offensive ditches or watercourses lying near to or forming the boundaries of their districts. The next two sections apply only to *urban* districts. Section 49 authorises the inspector of nuisances to give notice to the owner or occupier of premises to remove collections of manure or other

offensive matter, and if not removed within twenty-four hours any such filth accumulations become the property of the authority, to be disposed of by them. Section 50 empowers the *urban* authority to give public notice requiring the periodical removal of manure or other refuse matter from mews and other premises, and failing compliance penalties are incurred.

7. *Water Supply* (Sections 51-70).—Under these sections local authorities are empowered to construct water-works, or to hire or purchase such works, or to contract for supplying water to any part or parts of their districts, or to neighbouring districts if sanctioned by the Local Government Board. They have the same powers of carrying mains within or without their districts as for laying sewers. Section 55 renders it incumbent on them to provide and keep, in any water-works constructed or purchased by them, a supply of pure and wholesome water. They have power to charge water-rates or rents, or may supply water by meter. When houses are without water they may on notice require owners to provide a proper supply if it can be furnished at a cost not exceeding the water-rate authorised by any local Act, or at a cost not exceeding twopence a week, or such other cost as the Local Government Board may determine to be reasonable, and failing compliance with the notice they may themselves do all such works as are necessary, and recover the expenses incurred in a summary manner (Section 62). All existing pumps, wells, cisterns, reservoirs, and works used for the gratuitous supply of water are vested in the local authority, and they may maintain such wells or works, even though the district may be supplied by a public company (Section 64). Under Section 68 heavy penalties are incurred for polluting any stream, reservoir, pond, or place for water with gas washings; and Section 69 empowers any local authority to take proceedings for the purpose of protecting any water-course within their jurisdiction from pollutions arising from sewage either within or without their district. (As will be shown subsequently, these powers are further supplemented by the Rivers Pollution Act, 1876). Section 91 empowers a local authority to obtain a justice's order for the closing of any well or cistern used, or likely to be used, for drinking purposes, when the water is so polluted as to be injurious to health, and the court of summary jurisdiction may order the water to be analysed at the expense of the authority. (Further powers as regards water supply are provided by the Public Health (Water) Act, 1878.) (See *post.*)

8. *Cellar Dwellings.*—Section 71 enacts that no cellar built or rebuilt since 1848 can be occupied separately as a dwelling, which was not lawfully so let at the time of the passing of the Act, and

under Section 72 no existing cellars can be let or occupied unless under the following conditions :—(1) The height of the cellar must be at least 7 feet from floor to ceiling—3 feet of which must be above the surface of the adjoining street or ground. (2) An open area, at least $2\frac{1}{2}$ feet wide in every part, and 6 inches below the level of the floor, must extend along the entire frontage, and though such area may be crossed by steps, these must be 6 inches clear of the wall, and not across or opposite any window. (3) The cellar must be effectually drained by a drain at least 1 foot below the level of the floor. (4) There must be proper closet accommodation. (5) There must be a fireplace and chimney, and a window made to open of an area at least 9 square feet clear of the window sash. If, however, there is a back cellar let with the front cellar, the window of such cellar need only be 4 square feet in area. Section 73 imposes a penalty on any person letting, or allowing to be occupied, any cellar contrary to the provisions of the Act; Section 74 declares that any cellar is deemed to be occupied as a dwelling if any one passes the night in it; while Section 75 gives power to close cellars on two convictions within three months.

9. *Common Lodging-Houses* (Sections 76-89). — Every local authority is required to keep a register of all common lodging-houses in their district, and to see that all such houses and the keepers thereof are registered. They shall not register any house as a common lodging-house until it has been inspected and approved; they may refuse to register any lodging-house keeper unless he produces a satisfactory certificate of character; and they may require every registered keeper to affix the words, "registered common lodging-house," in some conspicuous place on the outside of such house. Every local authority *shall* also from time to time make bye-laws—(1) for fixing the number of lodgers, and for the separation of the sexes; (2) for promoting cleanliness and ventilation; (3) for notifying cases of infectious disease and taking proper precautions; and (4) generally for the well-ordering of such houses.

When a lodging-house is without a proper water-supply the local authority may enforce such supply if it can be provided at a reasonable cost. Further, the keeper of a lodging-house is required to lime-wash the walls and ceilings twice a year (in the first week of April and October); to make a return of beggars or vagrants received into the house to the local authority, when requested to do so, in writing; to give immediate notice to the medical officer of health and the relieving officer of any case of fever or infectious disease; and to give free access at all times to any officer of the authority to any part of the house.

Here it may be noted that the bye-laws which must be framed for all common lodging-houses should refer to the following particulars:—

(*a*) Notice stating the *maximum number* allowed in each room should be affixed to the doors or exhibited in the rooms—the number to be based on an allowance of 300 cubic feet for each adult, and 150 cubic feet for each child under ten. (*b*) *Separation of the sexes.*—No child above ten should sleep in the same room with persons of the opposite sex, and no bed should be occupied by more than one male above ten years. Rooms should be set aside for the sole use of married couples, provided that every bed is screened off. (*c*) *Cleanliness of premises.*—All floors should be swept daily, and washed once a week; and all windows, painted surfaces, and fittings kept clean. Yards, etc., must be kept clean and in good order. (*d*) *Closets and ash-pits.*—These must be kept clean and in good order. (*e*) *Sleeping-rooms.*—Windows must be opened for an hour every morning and afternoon, except on account of stress of weather, or when the room is occupied by a sick person. Beds must be well aired for an hour each day, by stripping off the bed-clothes, and must not be reoccupied within an interval of eight hours after being vacated. Every sleeping-room must be provided with sufficient bedsteads, beds, bedding, and utensils for the maximum number of lodgers allowed in the room. All slops and refuse must be removed every day before 10 A.M., and all utensils cleaned daily. (*f*) *Washing.*—A sufficient supply of basins, water, and towels must be provided and kept clean for the use of the lodgers. (*g*) *Precautions against infectious disease.*—Besides giving immediate notice of any cases of infectious disease, the keeper must at once take all necessary precautions. No person except a relative or attendant must occupy the same room; and as regards removal of patients to hospital, disinfection, etc., he must obey the instructions of the medical officer of health. He must not receive any lodger into a room in which there has been an infectious case until two days after cleansing and disinfection have been completed. (*h*) *A copy of the bye-laws* must be placed in some conspicuous part of the house, and must not be concealed or altered.

As several sections of the Act itself contain important regulations not included in the bye-laws, these should also be printed and supplied to every keeper of a common lodging-house.

According to a memorandum issued by the Local

Government, no house should be licensed as a lodging-house whose sanitary condition and surroundings are not in every respect satisfactory. In addition to the sleeping-rooms there should be at least one common sitting-room, exclusive of the kitchen.

Although there is no definition of a common lodging-house in the Act, it is generally understood to be "that class of house in which persons of the poorer class are received, and, though strangers to one another, are allowed to inhabit one common room."

10. *Houses let in Lodgings.*—Section 90 empowers the Local Government Board to declare the enactment contained in the section to be in force within the district, or any part of the district, of a local authority, and after publication of the notice the authority has full power to make bye-laws similar to those which apply to common lodging-houses. (See 1885 Act *post.*)

11. *Nuisances* (Section 91).—As this section is a very important one, it may be considered more fully in detail. According to Lumley, though the word nuisance as used in this section does not include every common law nuisance, it is not necessary that a nuisance to be within the Act should also be injurious to health, inasmuch as the terms used are disjunctive,—nuisance *or* injurious. It is sufficient if the nuisance interferes with personal comfort.

The several classes of nuisances are defined by the section as follows:—

(1) "Any premises in such a state as to be a nuisance or injurious to health:

(2) "Any pool, ditch, gutter, watercourse, privy, urinal, cesspool, drain, or ashpit so foul or in such a state as to be a nuisance or injurious to health:

(3) "Any animal so kept as to be a nuisance or injurious to health:

(4) "Any accumulation or deposit which is a nuisance or injurious to health:

(5) "Any house or part of a house so overcrowded as to be dangerous or injurious to the health of the inmates, whether or not members of the same family:

(6) "Any factory, workshop, or workplace not kept in a cleanly state, or not ventilated in such a manner as to render harmless as far as practicable, any gases, vapours, dust, or other impurities generated in the course of the work carried on therein, that are a nuisance, or injurious to health, or so overcrowded while work is carried on, as to be dangerous or injurious to the health of those employed therein:

(7) "Any fireplace, or furnace which does not as far as practicable consume the smoke arising from the combustible used therein, and which is used for working engines by steam, or in any mill, factory, dyehouse, brewery, bakehouse, or gaswork, or in any manufacturing or trade process whatsoever; and any chimney (not being the chimney of a private dwelling-house) sending forth black smoke in such quantity as to be a nuisance, shall be deemed to be nuisances, liable to be dealt with summarily in manner provided by this Act: Provided—

"First. That a penalty shall not be imposed on any person, in respect of any accumulation or deposit necessary for the effectual carrying on any business or manufacture, if it be proved to the satisfaction of the court that the accumulation or deposit has not been kept longer than is necessary for the purposes of the business or manufacture, and that the best available means have been taken for preventing injury thereby to the public health:

"Secondly. That where a person is summoned before any court in respect of a nuisance arising from a fireplace, or furnace, which does not consume the smoke arising from the combustible used in such fireplace or furnace, the court shall hold that no nuisance is created within the meaning of this Act, and dismiss the complaint, if it is satisfied that such fireplace or furnace is constructed in such manner as to consume as far as practicable, having regard to the nature of the manufacture or trade, all smoke arising therefrom, and that such fireplace or furnace has been carefully attended to by the person having the charge thereof."

The sanitary defects implied in sub-section (1) have reference, for the most part, to the cleansing or white-washing of dirty houses; the repair of roofs that let in the rain; the repair of walls and uneven floors; the opening of fastened windows to improve the ventilation; the repair of closets; the relaying of defective drains; the ventilation, trapping, or disconnection of house-drains; the removal of privies or middens near houses or wells;

the prevention of dampness as far as possible; the repair of yards, courts, and paving; and, especially in rural districts, the sanitary improvement of farm-yards adjoining the dwellings. The filthy, sloppy condition of many of these yards is often caused by want of proper spouting to the farm buildings, as well as defective drainage; and another common source of nuisance, connected with them, is the proximity of the offensive pig-wash cistern to the farm-house.

(2.) This sub-section requires no further comment than this, that whenever any offensive smell is given off, by any pool, ditch, etc., whether it be in the proximity of dwellings, or near any frequented road or footpath, there is sufficient evidence of the existence of a nuisance which calls for removal.

(3.) This sub-section applies to pig-styes, fowl-pens, dog-kennels, cow-byres, etc. In dealing with nuisances of this description, it often happens that the abatement may be effected in various ways. For example, a nuisance arising from a pig-stye may be abated sometimes by keeping the animal in a more cleanly way, by lessening the number of pigs, by properly draining the pig-stye, by removing the pig-stye, if it be too near a dwelling, or too near a frequented path, or by prohibiting the keeping of pigs altogether. It may safely be laid down as a rule, that pig-styes, close to dwellings, or under bed-room windows, will always be more or less a nuisance, no matter how carefully the animal may be kept. In *urban* districts, bye-laws based on the Model Bye-Laws of the Local Government Board, prescribe a distance of from 60 to 100 feet from any dwelling-house. If several kinds of animals are kept in the same shed or yard, so as to create nuisance, notice for abatement may be given under sub-section (1).

(4.) In this sub-section are included offensive manure-

heaps or other filth-accumulations, which are close to dwelling-houses or frequented paths. It also applies to offensive refuse-heaps of every kind, with the proviso already quoted in respect of any accumulation or deposit necessary for the carrying on of any business or manufacture.

(5.) This sub-section throws considerable responsibility on the medical officer of health, as to what constitutes overcrowding. But a safe rule to follow is to adopt as a minimum the standard laid down in the Model Bye-Laws of the Local Government Board, namely, 400 cubic feet for single room dwellings, and 300 for sleeping rooms per adult, and allowing half these amounts for every child. In the interests of morality it is unfortunate that the definition was not extended so as to prevent grown-up children of both sexes sleeping in the same room, or in the same room with their parents.

(6.) The provisions of this sub-section apply to all factories, work-shops, or work-places in respect to cleanliness, ventilation, overcrowding, lime-washing, and freedom from nuisance generally.

(7.) In order to obviate nuisance coming within this sub-section, all furnaces or factory fireplaces should have chimneys of sufficient height, and should be provided with smoke-consuming apparatus. Very often it is found that nuisance arises from neglect in stoking.

12. *Abatement of Nuisances.*—(1.) It is the duty of every local authority to cause to be made from time to time inspection of their district with a view to ascertain what nuisances exist, and to enforce the provisions of this Act in order to abate the same (Section 92).

(2.) Information of any nuisance under the Act may be given by any person aggrieved, by any two inhabitant householders, by any officer of the local authority, by the relieving officer, or by any officer of the police (Section 93).

(3.) If satisfied of the existence of a nuisance, the local authority must serve a notice on the person responsible for the nuisance, or

if such person cannot be found, on the owner or occupier of the premises on which the nuisance arises, requiring him to abate the same within a time to be specified in the notice, and to execute such works, and do such things as may be necessary for that purpose. When the nuisance arises from any want, or defective construction, of any structural convenience, or where there is no occupier, notice must be served on the owner ; or if the person responsible for the nuisance cannot be found, and neither the owner nor occupier is responsible, the local authority may themselves abate the same without further order (Section 94).

(4.) If the person on whom the notice is served fails to comply with any of its requisitions within the time specified, or if the nuisance though abated is likely to recur, the local authority must cause a complaint to be made before a justice, and such justice shall thereupon issue a summons requiring the person on whom the notice is served to appear before a Court of Summary Jurisdiction (Section 95).

(5.) If the Court is satisfied that the alleged nuisance exists, or though abated is likely to recur, it shall make an order requiring compliance with any or all of the requisitions of the notice, or any order prohibiting recurrence of the nuisance, and directing the execution of any works necessary for abatement or prevention of recurrence. The Court may further impose a penalty not exceeding five pounds, and shall also give directions as to the payment of costs (Section 96).

(6.) When the nuisance is such as to render a house unfit for human habitation, the Court may order the house to be closed until it is rendered fit for occupation, and when satisfied that it has been rendered habitable, the Court may determine the previous order by a further order declaring the house to be habitable, after which it may be let or occupied (Section 97).

(7.) Any person not obeying the order of the Court, or who fails to use due diligence to carry out such order, is liable to a penalty not exceeding ten shillings per day during his default, or to a penalty not exceeding twenty shillings per day if he acts knowingly and wilfully contrary to an order during such contrary action. Further, the local authority may themselves execute the order, and recover the expenses incurred from the person on whom the order is made (Section 98). Power of appeal, however, is granted to the Court of Quarter Sessions, and no penalty is incurred, nor can the order be executed until such appeal is heard or ceases to be prosecuted (Section 99).

(8.) When the person responsible for the nuisance, or the owner or occupier, cannot be found, the order of the Court for abate-

ment may be addressed to and executed by the local authority (Section 100), and any matter or thing removed by the authority in abating any nuisance under this Act may be sold by public auction (Section 101).

(9.) The local authority, or their officers, have rights of entry on any premises for the purpose of examination as to the existence of any nuisance thereon between the hours of 9 A.M. and 6 P.M., and in the case of nuisance on business premises, at any hour during which such business is carried on. If admission is refused, a justice's order for entry may be obtained (Section 102). Any person who refuses to obey such order is liable to a penalty not exceeding five pounds (Section 103).

(10.) Complaint of nuisance may be made to a justice by any person aggrieved thereby, or by any inhabitant, or by any owner of premises, and upon such complaint the like proceedings detailed in the previous sections shall be taken as in the case of complaint made to a justice by a local authority, provided that the Court may adjourn the hearing for examination of the premises. The Court may also authorise a constable or other person to do all necessary acts to abate the nuisance, and to recover the expenses incurred from the person on whom the order is served in a summary manner, and such constable or authorised person shall have like powers of entry, and be under the like restrictions as if he were an officer of the local authority (Section 105).

(11.) Where it is proved to the satisfaction of the Local Government Board that a local authority has made default in relation to the abatement of nuisances under this Act, the Board may authorise any officer of police within the district of the authority to institute proceedings for abatement, and may recover the expenses incurred from the defaulting authority. Such officer, however, has no power of entry without consent, or without the warrant of a justice (Section 106).

(12.) Where a nuisance appears to be partially or wholly caused by some act or default outside the limits of their district, a local authority is nevertheless authorised to take proceedings for abatement in the same way as if the nuisance were caused entirely within their district (Section 108). This section is extended to the vestries within the metropolitan area.

(13.) Where two convictions for overcrowding in a house have taken place within three months, the Court of Summary Jurisdiction may, on the application of the local authority, direct the closing of the house for such period as the Court may deem necessary (Section 109).

(14.) In respect to nuisances, any ship or vessel, not under the

command of any officer bearing Her Majesty's Commission, or belonging to any Foreign Government, lying in any harbour, river, or water within the district of any local authority, is subject to the jurisdiction of the authority as if it were a house. If lying in any harbour or water not within their district, it shall be deemed to be within such district as the Local Government Board may direct, and where no local authority has been prescribed, then within the nearest district (Section 110).

13. *Offensive Trades* (Sections 112-115).—These sections apply only to *urban* sanitary authorities, and render it illegal to establish the following offensive trades in their districts without their consent in writing, viz.—the trade of *blood-boiler*, *bone-boiler*, *fell-monger*, *soap-boiler*, *tallow-melter*, or *tripe-boiler*, or "any other noxious or offensive trade, business, or manufacture," and any one establishing such business without the consent of the authority renders himself liable to heavy penalties.

As regards the prohibition of the establishment of offensive trades generally, it will devolve upon the *urban* authority to show that the trade is either one of those specially mentioned, or that it comes under the same category, and that it is essentially an offensive trade, apart altogether from mismanagement. In commenting upon this section, Lumley remarks that it is impossible to enumerate the various trades which may be noxious or offensive within its meaning; nor do the cases in which the Courts have interfered afford any guidance in the determination of the question, for a trade not noxious may be so conducted as to be an actionable nuisance—as in the case of brick-burning. Nevertheless a large number of offensive trades, which may not come within the above restriction, can be dealt with under Section 114 as follows:—

Where any candle-house, melting-house, melting-place, soap-house, slaughter-house, or any building or place for boiling offal or blood, or for boiling, burning, or crushing bones; or *any* manufactory, building, or place used for any trade, business, process, or manufacture causing effluvia, is certified by the medical officer of health, or by any two medical practitioners, or by any ten inhabitants of the district, to be a nuisance or injurious to health, the

urban authority shall direct complaint to be made before a justice, who may summon the offender to appear before a Court of Summary Jurisdiction, or the authority, if they think fit, may institute proceedings in any superior Court of law or equity for the abatement of the nuisance so certified. Under Section 115 power is also given to an *urban* authority to institute proceedings on such certificate in the case of a trade nuisance affecting the inhabitants of their district though the nuisance arises without the district, and the section extends this power to vestries within the metropolitan area. Further, every *urban* sanitary authority is empowered to make bye-laws in respect to such offensive trades as have been established in their district with their consent (Section 113).

In addition to the six trades specifically mentioned above, the Model Bye-Laws issued by the Local Government Board contain bye-laws affecting the following trades:—*blood-drier, leather-dresser, tanner, fat-melter* or *fat-extractor, glue-maker, size-maker,* and *gut-scraper.* Without entering into details, these bye-laws provide for the conveyance and storage of foul and offensive materials in properly-constructed vessels or receptacles covered with tight-fitting lids; for cleanliness of premises by requiring the construction of impervious floors and walls where necessary, by washing the same daily if required, and lime-washing parts of walls, not cemented or otherwise rendered impervious, as well as ceilings, at least twice a year; for effectual drainage, and the cooling of all hot liquid refuse before discharging into any drain; for the removal of all waste material without creating nuisance; and, above all, for the adoption of the best practicable means for rendering all vapours given off in the process of trade or manufacture innocuous. In dip candle-making or fat-melting, the fat is melted either in pans heated by an open fire, by free steam and sulphuric acid, or in steam-jacketed pans. Melting by an open fire is always productive of great nuisance, unless the vapours are consumed by fire applied with air at the top of the pan, and this necessitates a strong draught, such as can

only be obtained by a high chimney shaft. In populous neighbourhoods, the only method which can be carried on successfully without nuisance is melting by free steam, or in steam-jacketed pans with close-fitting covers, and even then, the vapours must be passed through a condensing apparatus, and afterwards, if necessary, through the furnace fire, or a fume-cremator.

According to Dr. Ballard, offensive gases or vapours, when drawn off or collected, may be dealt with in five different ways. "(1.) They may be discharged into the atmosphere at such an elevation as that they shall be so diluted before reaching the ground as not to be offensive. When this will not suffice, other means must be used. (2.) If the evolved matters be condensible by cold, they may be passed through an appropriate condensing apparatus. (3.) If soluble in water, they may be submitted to the action of water in an appropriate apparatus, or similarly, to the action of any other liquid better calculated to absorb them. (4.) Sometimes, in like manner, solid substances, with which the effluvia have chemical affinity, may be used with advantage, either in powder or otherwise. (5.) If the evolved matters be combustible, they may be burned by conducting them through a fire." —(*Supplement to Local Government Board Report*, 1876.)

Gas-works often give rise to nuisance, especially in small towns or villages, where the process of manufacture and purification is imperfectly carried out. In addition to lime-purifiers, there should always be purifiers containing oxide, or other salt of iron, to remove the sulphuretted hydrogen. Usually, however, only lime-purifiers are employed, and the lime in these is so seldom changed, that not only is there intolerable nuisance produced when the purifiers are emptied, but the spent lime is so saturated with sulphuretted hydrogen and other offensive effluvia, that it cannot be removed from the works, unless in

properly covered carts or trucks, without creating further nuisance. The ammoniacal liquor from gas-works should be removed in properly covered tanks or barges.

Before a conviction can be obtained in respect to established trades, it will be necessary to prove to the satisfaction of the Court that the best practicable means for the abatement of nuisance have not been adopted; and as the medical officer of health is liable, in most cases, to be called upon to give skilled evidence, it is necessary that he should be well acquainted with the process of manufacture, or the details of the trade complained of, the nature of the effluvia given off, and the best means which should be adopted to prevent nuisance. Such knowledge can, of course, only be obtained by making himself well acquainted with trade processes generally, and it must necessarily be supplemented by a thorough acquaintance with practical chemistry. Unless the medical officer of health is an expert in these matters, the best course to pursue is to recommend the manufacturer or tradesman, against whom complaint is made, to call in some competent person to advise him as to what steps he should take to prevent nuisance; and he should also recommend the sanitary authority to consult an expert, who would give evidence before the magistrates if necessary. (For special information on trade nuisances generally see Dr. Ballard's Reports to the Local Government Board, and Wynter Blythe's *Manual of Public Health*. See also page 117.)

13. *Unsound Meat, etc.*—Any medical officer of health or inspector of nuisances may, at all reasonable times, inspect and examine any animal, carcase, meat, poultry, game, flesh, fish, fruit, vegetables, corn, bread, flour, or milk exposed for sale, or deposited in any place for the purpose of sale, and intended for the food of man, and if any such animal, carcase, etc., appears to him to be diseased, unsound, or unwholesome, and unfit for the food of man, he may seize the same and have it removed, in order that it

may be dealt with by a justice, who, if satisfied that it is unfit for human food, shall condemn it and order it to be destroyed. The proof that it was not intended for the food of man rests with the party charged, who, on conviction, is liable to fine or imprisonment (Sections 116, 117). Any person obstructing an official or his assistant in the discharge of his duty is liable to a penalty (Section 118), and, on complaint being made on oath, a justice may grant a search-warrant (Section 119).

In the event of a search-warrant being required, no penalty is incurred for concealment beyond the seizure and removal of the unsound animal, carcase, meat, etc., to be dealt with by a justice, unless it can be proved that it was intended for the food of man. Diseased animals can be seized under Section 116, if exposed for sale. Very often, with regard to bad meat, the defence set up is that such meat was not intended for the food of man, but for feeding dogs, or to be boiled down with other offal as the case may be. So far, however, as the medical officer of health is concerned, he should endeavour, as far as possible, to confine his evidence to the question as to whether the meat seized by the inspector is or is not fit for the food of man, and whether it appears to him to have been dressed in the usual way, leaving the rest of the evidence to be given by the sanitary inspector or other witnesses. Should the medical officer of health deem it to be his duty to himself seize, he should call in the assistance of the sanitary inspector, or a policeman, or some other person, to have the carcase, meat, etc., so seized to be removed, in order that it may be dealt with by a magistrate. It need hardly be said that it is always advisable to take careful notes of all the points on which he bases his opinion that the meat, etc., submitted to him for inspection, or which he may himself seize, is unfit for the food of man, and these notes he can use when he gives his evidence in court.

It should also be observed, that no proceedings can be taken in respect to articles already sold, nor in respect to certain articles of food, such as butter, eggs, cheese, etc., which are not specifically mentioned. These defects, however, are fully met by the Public Health (Amendment) Act of 1890 (see *post*), and by Section 15 of the Markets and Fairs Clauses Act, incorporated with the Public Health Act, which enacts that "any person, who shall sell or expose for sale any unwholesome meat or provisions in the market or fair, shall be liable to a penalty not exceeding five pounds for every such offence."

The diseases which render the flesh of animals unfit for the food of man have already been discussed in Chapter II. (see page 36), and directions for the examination of butcher meat, and other articles of food have been given in Section VII. of the same chapter (see page 52).

14. *Infectious Diseases and Hospitals.*—Section 120 makes it incumbent on every local authority, on the certificate of the medical officer of health, or of a medical practitioner, to give notice to the owner or occupier for the cleansing or disinfecting of any house or part thereof, or of any articles contained therein, which are likely to retain infection. Failing compliance, a penalty is incurred, and the local authority may themselves cleanse or disinfect, and recover the costs, or they may undertake to do the necessary work, in the first instance, with the consent of the occupier. A local authority is further empowered to destroy infected clothing, bedding, or other infected articles, and to give compensation for the same (Section 121); to provide a disinfecting place with all proper apparatus and appliances, and disinfect free of charge (Section 122); and to provide an ambulance or carriage, and pay for the conveyance of patients to hospital (Section 123).

Section 124 enacts that where a hospital has been provided by a local authority, and is within convenient distance, a justice may, on the certificate of a qualified medical practitioner, order any person suffering from dangerous infectious disease to be removed to such hospital, if he is without proper lodging or accommodation, or lodged in a room occupied by more than one family, or is on board any ship or vessel, or lodged in any common lodging-house; and any person who wilfully disobeys or obstructs the execution of such an

order, is liable to a penalty. Further, a local authority is empowered, by Section 125, to make regulations for the removal to any hospital to which they are entitled to send patients, and for retaining, as long as may be necessary, any persons brought within their district by any ship or boat, who were suffering from dangerous infectious disease; and such regulations, which must be subject to the approval of the Local Government, may impose a penalty on offenders. Section 126 enacts that any person, who, (1) while suffering from dangerous infectious disease, wilfully exposes himself without taking proper precautions, in any street, public place, shop, inn, or public conveyance, or enters any public conveyance without previously notifying to the owner or conductor that he is so suffering; or (2) being in charge of any person so suffering, so exposes such sufferer; or (3) gives, lends, sells, transmits, or exposes, without previous disinfection, any bedding, clothing, rags, or other things which have been exposed to infection, shall be liable to a penalty not exceeding five pounds, provided that no proceedings shall be taken against persons transmitting with proper precautions any bedding, clothing, or other articles for the purpose of having the same disinfected (see page 530).

According to Section 127, the owner or driver of any public conveyance, who knowingly conveys a person suffering from dangerous infectious disease, and who does not immediately provide for the disinfection of such conveyance, renders himself liable to a penalty, but no such owner or driver shall be required to convey any person so suffering, unless he has been paid a sum sufficient to cover any loss or expense incurred. Section 128 renders any person liable to a penalty, who knowingly lets for hire any house, room, or part of a house, in which any person has been suffering from any dangerous infectious disorder, without having the same, and all infected articles, disinfected to the satisfaction of a medical practitioner, and certified in writing by him, and the section applies to any inn-keeper who shall be deemed to let for hire part of a house to any person admitted as a guest into his inn. Section 129 enacts that any person, letting or offering for hire any house or part of a house, who, on being questioned by any person negotiating for the hire of such house, or part of a house, as to the fact of there being, or within six weeks previously having been therein, any person suffering from any dangerous infectious disorder, knowingly makes a false answer to such question, shall be liable to a penalty of twenty pounds, or to imprisonment, with or without hard labour, not exceeding one month. Section 130 empowers the Local Government Board to make, alter, or revoke regulations for the treatment of persons affected with cholera, or any other epidemic or infectious

disease, and for preventing the spread of such diseases as well on the seas, rivers, and rivers of the United Kingdom, and on the high seas within three miles of the coasts thereof, as on land, and may declare by what authority or authorities such regulations shall be enforced and executed.

With regard to *hospitals*, any local authority is empowered by Section 131 to provide hospitals or temporary places for the reception of the sick; they may themselves build such hospitals, or contract for their use, or enter into any agreement with any person having the management of any hospital, for the reception of cases belonging to their district; or two or more local authorities may combine to provide a common hospital. Section 132 empowers a local authority to recover the cost of maintenance of any patient, who is treated in any such hospital, who is not a pauper.

With regard to this section, it may be remarked in passing, that inasmuch as the removal of a patient to a hospital is primarily intended for the protection of the public, by preventing the spread of infectious disease, it would be manifestly unfair, in the great majority of cases, to enforce payment, and would greatly diminish the usefulness of such hospitals. All patients who are treated in the general wards should be treated free of charge, but where there are private wards and patients or their friends are desirous of obtaining special seclusion and nursing, full payment should of course be demanded. It may also be observed that masters of households and shop-keepers, are often very willing to pay for their servants or assistants. With proper tact, on the part of the medical officer of health in enlisting the co-operation of medical attendants, there will generally be little difficulty experienced in inducing patients to enter the hospital, who are fit to be removed, and whose removal is considered advisable, either for the protection of the household, or for public safety. But no case should be admitted without a certificate of fitness from the medical attendant, nor, unless under very exceptional circumstances, should any patient be removed without his concurrence.

For detailed information with regard to hospitals and infectious diseases, etc., see Chapters XIV. and XVI.

15. *Prevention of Epidemic Diseases.*—Section 134 empowers the Local Government, whenever any part of England appears to be threatened, or is affected by any formidable epidemic or endemic infectious disease, to make, alter, or revoke regulations, for all or any of the following purposes :—(1) speedy interment of the dead ; (2) house to house visitation ; (3) for the provision of medical aid and accommodation ; for the promotion of cleansing, ventilation, and disinfection, and for guarding against the spread of disease ; and to declare such regulations to be in force within the whole or any parts of the district of a local authority, and to apply to any vessels, whether in inland waters or arms of the sea, within the jurisdiction of the Lord High Admiral of the United Kingdom, for the period mentioned in such order. All such orders and regulations must be published in the London Gazette (Section 135) ; and local authorities are bound to see that they are properly executed (Section 136) ; while power of entry on any premises or vessel is given to the local authority or their officers, for the purpose of executing or superintending the execution of any regulations so issued (Section 137). Section 138 provides for the payment of any poor law medical officer or private medical practitioner, who performs any medical service on board any vessel under such regulations ; and Section 139 empowers the Local Government Board to combine local authorities for the purpose of the provisions of the Act contained in the above sections, relating to the prevention of epidemic diseases. Section 140 imposes a penalty on wilful violation or obstruction.

16. *Mortuaries.*—The obligations conferred on local authorities, with regard to the provision and maintenance of mortuaries and post-mortem-rooms, and the powers conferred on justices to order the removal of dead bodies to mortuaries, contained in Sections 141, 142, and 143, have already been discussed in Chapter XVII. (see page 538).

17. *Regulation of Streets and Buildings.*—The following sections apply exclusively to *urban* authorities :—

Section 149 vests all public streets, in *urban* districts, in the sanitary authority, who shall cause them to be levelled, paved, metalled, channelled, flagged, and repaired or altered as they may

think fit. Section 150 empowers the authority to require the owners of property, abutting on any private street, or part of a street, to level, pave, sewer, light, or make good such street, or part of a street, and in case of default, the authority may themselves do the work, and recover the expenses from the owners, according to the frontage of their respective premises.

Section 157 empowers every *urban* sanitary authority to make bye-laws, with respect to the following:—

(1.) Level, width, and construction of new streets, and provisions for the sewerage thereof.

(2.) Structure of walls, foundations, roofs, and chimneys of new buildings (see pages 382-385).

(3.) Sufficiency of the space about buildings to secure a free circulation of air (see page 382), and with respect to the ventilation of buildings (see page 385).

(4.) The drainage of buildings (see page 305); to water-closets (page 296); earth-closets, privies, ash-pits (page 328); cesspools (page 316); and to the closing of buildings unfit for human habitation; and prohibition of their use for such habitation. Section 158 provides that where a notice, plan, or description of any work is required by any bye-law, made by an *urban* authority, the authority shall, within one month, approve or disapprove of the same, and if the work is commenced after written notice of disapproval or without approval, and is not in conformity with the bye-laws, the authority may cause so much of the work as has been executed to be pulled down or removed, and may recover the expenses incurred in a summary manner. Section 159 defines the erection of a new building to be the re-erection of any building pulled down to or below the level of the ground floor, or of any frame-building of which only the frame-work is left down to the ground floor, or the conversion into a dwelling-house of any building not originally constructed for human habitation, or the conversion into more than one dwelling-house of a building, originally constructed as one dwelling-house only.

Section 160 incorporates certain provisions of the Towns Improvement Clauses Act 1847, with respect to the naming of streets and the numbering of the houses, the line of the streets and removing obstructions, etc., and with respect to ruinous or dangerous buildings. These provisions render it incumbent on the surveyor of an *urban* authority, whenever he is satisfied that any building or wall is in a ruinous state so as to be dangerous to passers by, or to the inhabitants of neighbouring houses, to cause a fence to be put up, and to order the owner forthwith to secure or pull down such building, and in default the surveyor may obtain a justice's

order to carry out the necessary works, and may recover the expenses. They also empower an *urban* authority to compel the owner of any building, adjoining or near a street, to provide within seven days efficient eaves, gutters, and rain-pipes.

18. *Public Pleasure Grounds.*—Section 164 empowers *urban* authorities to provide places of public recreation and make bye-laws for the regulation of the same.

19. *Markets and Slaughter-Houses.*—Section 166-168 empower *urban* authorities to provide market-places, purchase or lease land for the purpose, furnish all necessary appliances and equipments, and make bye-laws for the regulation of such market-places.

20. *Slaughter-Houses.*—Section 169 empowers any *urban* authority to provide abbattoirs or public slaughter-houses, and makes it obligatory to make bye-laws for the management, and charges for the use of the same. For the purpose of enabling any *urban* authority to regulate slaughter-houses within their district the provisions of the Towns Improvement Clauses Act, 1847, with respect to slaughter-houses, are incorporated with the Public Health Act, 1875. These provisions empower *urban* authorities to license slaughter-houses and knackers' yards, and without such license no place shall be used for such purposes which was not so used at the time of the passing of the 1875 Act. Every place used as a slaughter-house or knacker's yard shall be registered by the owner or occupier in a book kept for that purpose, and if any person is convicted of killing or dressing any cattle contrary to the provisions of the Public Health Act, or of the non-compliance with any bye-laws or regulations, the justice before whom he is convicted may suspend the license for two months, and on a second conviction may revoke the license. Further, these provisions render it obligatory on every *urban* authority to make bye-laws in respect to slaughter-houses and knackers' yards within their districts.

Bye-laws respecting slaughter-houses, in addition to laying down conditions with respect to licences and registration, impose the following:—(1) Free access for the purpose of inspection to the sanitary authority and their officers; (2) a supply of water to every animal kept in a lair prior to slaughter; (3) cattle must be secured by the head in order that they may be felled with as little pain as possible; (4) the drainage, water-supply, and ventilation must be satisfactory. (5) In order to secure cleanliness, the walls and floor must be kept in good

order and repair, and must be thoroughly cleansed three hours after slaughtering; and the walls and ceiling must be lime-washed or otherwise cleansed four times every year, namely, within the first ten days of March, June, September, and December. (6) No dog or other animal must be kept in any slaughter-house, nor any other animal, unless intended for slaughter upon the premises, and these only in proper lairs, and not longer than is necessary for preparing it for slaughter, by fasting or otherwise. (7) Suitable vessels, made of non-absorbent materials, and with close-fitting covers, must be provided for the reception of blood, manure, garbage, and other refuse immediately after the slaughtering; and all such refuse must be removed within twenty-four hours, and the vessels forthwith cleansed. (8) Further, all skins, fat, and offal, must be removed within twenty-four hours.

In a memorandum issued by the Local Government Board in 1877, the following instructions are given:—

In framing a model series of bye-laws the Board have considered that the statutory terms do not warrant the extension of the scope of the bye-laws to regulations directly affecting the structure of the premises. But in the discretionary power of licensing which has been conferred upon the sanitary authority the following rules as to site and structure should influence their decision upon each application for a license:—

(1.) The premises . . . should not be within 100 feet of any dwelling-house; and the site should be such as to admit of free ventilation by direct communication with the external air on two sides at least of the slaughter-house.

(2.) Lairs for cattle in connection with the slaughter-house should not be within 100 feet of a dwelling-house.

(3.) The slaughter-house should not in any part be below the surface of the ground.

(4.) The approach to the slaughter-house should not be on an incline of more than one in four, and should not be through any dwelling-house or shop.

(5.) No room or loft should be constructed over the slaughter-house.

(6.) The slaughter-house should be provided with an adequate

tank or other proper receptacle for water, so placed that the bottom shall not be less than six feet above the level of the floor of the slaughter-house.

(7.) The slaughter-house shall be provided with means of thorough ventilation.

(8.) The slaughter-house should be well paved with asphalte or concrete, and laid with proper slope and channel towards a gulley, which should be properly trapped and covered with a grating, the bars of which should not be more than three-eighths of an inch apart. Provision for the effectual drainage of the slaughter-house should also be made.

(9.) The surface of the walls in the interior of the slaughter-house should be covered with hard, smooth, impervious material to a sufficient height.

(10.) No water-closet, privy, or cesspool should be constructed within the slaughter-house. There should be no communication between the slaughter-house and any stable, water-closet, privy, or cesspool.

(11.) Every lair for cattle in connection with the slaughter-house should be properly paved, drained, and ventilated. No habitable room should be constructed over any lair.

Section 170 enacts that a legible notice bearing the words "Licensed Slaughter-House," or "Registered Slaughter-House," must be attached and maintained in some conspicuous place on every registered slaughter-house by the owner or occupier.

21. *Powers to appoint Committees.*—Section 200 empowers every *urban* authority to appoint out of their own number a committee for any purposes of the Act which in the opinion of such authority would be better regulated and managed by means of a committee; while Section 201 empowers a *rural* sanitary authority, at a meeting specially convened, to delegate for the current year the whole of their duties and powers to a committee consisting wholly of their own members, provided that one-third of such committee shall consist of *ex-officio* guardians; but in case an adequate number of such *ex-officio* guardians does not exist, then the number deficient shall be made up of elected guardians. A *rural* authority, or any committee so formed, is further empowered by Section 202, at any meeting specially convened for the purpose, to form for any contributory place within their district a parochial committee consisting wholly of members of the authority or committee, or partly of such members, and partly of rate-payers of the contributory place. Such parochial committee shall be deemed to be the agents of the authority, and may be empowered to incur expenses to an amount

not exceeding such amount as may be prescribed by the authority; but no powers can be delegated to a parochial committee except powers which the *rural* authority could exercise within such contributory place.

Parochial committees so constituted are often of great assistance in carrying out improvements in the drainage or water supply of villages, and serve to allay the usual opposition to such improvements.

22. *Legal Proceedings.*—Selected sections under this part of the Act need only require brief notice—

Section 251 enacts that all offences under this Act, and all penalties, forfeitures, costs, and expenses under this Act directed to be recovered in a summary manner, or the recovery of which is not otherwise provided for, may be prosecuted and recovered before a court of summary jurisdiction, constituted of two or more justices of the peace in petty sessions, or of some stipendiary magistrate. Section 252 provides that any complaint or information made or laid in pursuance of this Act shall be made or laid within six months from the time when the matter of such complaint or information respectively arose. Where any nuisance under this Act appears to be wholly or partially caused by the acts or defaults of two or more persons, Section 255 renders it lawful for the local authority or other complainant to institute proceedings against any one of such persons, or to include all or any two; and whenever such proceedings are taken relating to nuisances, it will be sufficient to designate the "owner" or "occupier" of the premises concerned without name or further description. Section 259 empowers any local authority to appear before any court, or in any legal proceedings by their clerk, or by *any officer or member authorised generally or in respect of any special proceeding by resolution of such authority*, and their clerk, or any officer or member so authorised shall be at liberty to institute and carry on any proceeding which the local authority is authorised to institute and carry on under this Act. Section 265 affords protection of local authority and their officers from personal liability when acting under the direction of such authority, except legal surcharges imposed by the public auditor. According to Section 266, notices, orders, and other such documents under this Act may be in writing or print, or partly in both; and Section 267 provides that such notices and orders required or authorised to be served under this Act may be served by delivering the same to or at the residence of the person to whom they are re-

spectively addressed, or where addressed to the *owner or occupier* of premises by delivering the same, or a true copy thereof, to some person on the premises, or if there is no such person on the premises who can be served, by fixing the same on some conspicuous part of the premises. They may also be served by post by a prepaid letter, and simply addressed by the description of the "owner" or "occupier" of the premises (naming them) in respect of which the notice is given, without further name or description. Further, Section 268 authorises appeal in certain cases to the Local Government Board, while Section 269 authorises appeal to Quarter Sessions where any person deems himself aggrieved by any rate made under the provisions of the Act, or by any order, conviction, or judgment given by any court of summary jurisdiction, subject to certain conditions and regulations.

23. *Alteration of Areas and Union of Districts.*—Section 270 empowers the Local Government Board by provisional order to dissolve any local government district, and to merge any such district in some other district or districts, and to make other alterations with respect to districts, whether *urban* or *rural;* while Section 271 empowers the Board to declare any *rural* district, or any portion of a *rural* district, to be a local government or *urban* district. The Board is also empowered by Section 276 to invest *rural* authorities with any or all of the powers of *urban* authorities. Section 277 renders it lawful for a *rural* authority, by a resolution to be approved of by the Local Government Board, to constitute any portion of their district a special drainage district, for the purpose of charging thereon exclusively the expenses of sewerage, water-supply, or of other works which may be declared special expenses, and thereupon such area will become a separate contributory place. On the application of local authorities to the Local Government Board, Sections 279 and 280 empower the Board, by provisional order, to form a united district—either for procuring a common water-supply ; for carrying out a joint-system of sewerage, or common outfall sewer ; or for other purposes of the Act, such as erecting a hospital for the use of the several districts concerned ; and the governing body of a united district shall be a joint-board, consisting of such members as the Local Government Board may determine by their provisional order. Section 283 enacts that any expenses incurred by a joint-board in pursuance of the Act shall be defrayed out of a common fund to be contributed by the contributory places *pro rata*, or otherwise as the order may determine ; and Section 284 provides that the joint-board shall issue their precept to each contributory local authority to pay their quota to such expenses. Section 285 gives power to local authori-

ties to execute works in adjoining districts with the consent of the local authorities of those districts, and to combine with neighbouring authorities for the execution of such works. Under 286, the Local Government Board, on any representation made to it, may by order unite districts for the appointment of a medical officer of health, but no *urban* district with more than 25,000 inhabitants can be included in such combination without the consent of the authority of such district.

24. *Powers of Local Government Board.*—Section 293 empowers the Board to cause to be made such inquiries as are directed by the Act, and such inquiries as they see fit in relation to any matters concerning the public health in any place, or any matters with respect to which their sanction, approval, or consent is required by the Act, and for the purposes of any such inquiry the inspectors of the Board have power, under Section 296, to take evidence on oath or attested by signature, to order the production of any papers and accounts, and to inspect places or matters required to be inspected.

Section 299 is a very important one, because it sets forth in detail the power of the Local Government Board to enforce performance of duty on defaulting local authorities. This section is therefore given in full:—

Where complaint is made to the Local Government Board that a local authority has made default in providing their district with sufficient sewers, or in the maintenance of existing sewers, or in providing their district with a supply of water, in cases where danger arises to the health of the inhabitants from the insufficiency or unwholesomeness of the existing supply of water, and a proper supply can be got at a reasonable cost, or that a local authority has made default in enforcing any provisions of this Act which it is their duty to enforce, the Local Government Board, if satisfied, after due inquiry, that the authority has been guilty of the alleged default, shall make an order limiting a time for the performance of their duty in the matter of such complaint. If such duty is not performed by the time limited in the order, such order may be enforced by writ of Mandamus, or the Local Government Board may appoint some person to perform such duty, and shall by order direct that the expenses of performing the same, together with a reasonable remuneration to the person appointed for superintending such performance, and amounting to a sum specified in the order, together with the costs of the proceedings, shall be paid by the authority in default; and any order made for the payment of such expenses and costs may be removed into the Court of Queen's

Bench, and be enforced in the same manner as if the same were an order of such Court.

Any person appointed under this section to perform the duty of a defaulting local authority shall, in the performance and for the purposes of such duty, be invested with all the powers of such authority other than (save as hereinafter provided) the powers of levying rates ; and the Local Government Board may from time to time by order change any person so appointed.

It may be remarked here that any person, according to this section, may make written complaint to the Local Government Board not only in respect to insufficient sewerage or water-supply, but in respect to any neglect on the part of a local authority in enforcing any of the provisions of this Act which it is their duty to enforce, and this last includes a wide range of sufficient grounds for complaint. (See, generally, Sections 15, 19, 40, 42, 46, 55, 72, 80, 92, 106, 120, and 141.) Section 106 is of special importance, because it empowers the Local Government Board to take action in respect to neglected nuisances. As will be shown subsequently, these powers of the Local Government Board are greatly extended by more recent Acts.

25. *Port Sanitary Authority.*—Section 287 empowers the Local Government Board to constitute by provisional order any local authority, whose district abuts on any part of a port in England, the authority for the whole or any part of such port. The Board may also combine two or more riparian authorities to constitute a port sanitary authority, or may constitute one port sanitary for two or more ports, and such authority may be constituted permanently or temporarily by provisional order. Further, any order constituting a port sanitary authority may assign to such authority any powers, rights, duties, capacities, liabilities, and obligations under this Act possessed by a local authority, so far as these are applicable to ships, vessels, boats, waters, or persons, viz. as regards nuisances under Section 110 ; infectious diseases and hospitals, Sections 120-133 (under Section 2 of the Public Health (Ships) Act) ; power of local authority to enter vessels, Section 137 ; prevention of epidemic disease, Section 134 ; mortuaries, Sections 141, 142 ; bye-laws, Sections 182-186 ; appointment of officers, Section 189 and other sections.

Under Section 130, the Cholera Order of 1890 issued by the Local Government Board supersedes all previous orders, and may therefore be fitly quoted here:—

Definitions.

Article 1. In this Order—The term "ship" includes vessel or boat; . . . the term "master" includes the officer, pilot, or other person, for the time being, in charge or command of a ship; the term "cholera" includes choleraic diarrhœa; . . . the term "medical officer of health" includes any duly qualified medical practitioner appointed by a sanitary authority to act in the execution of this order.

For the purposes of this order—

(1) So much of a customs port abutting on an urban or rural sanitary district as is nearer to such district than to any other, and is not included within the jurisdiction of any port sanitary authority, shall be deemed to be within such district.

(2) Every ship shall be deemed infected with cholera, in which there is or has been during the voyage, or during the stay of such ship in a port in the course of such voyage, any case of cholera.

I. Regulations as to Detention by Officers of Customs.

Article 2. If any officer of customs, on the arrival of any ship, ascertain from the master of such ship or otherwise, or have reason to suspect, that the ship is infected with cholera, he shall detain such ship, and order the master forthwith to moor or anchor the same in such position as such officer of customs shall direct; and thereupon the master shall forthwith moor or anchor the ship accordingly.

Article 3. While such ship shall be so detained, no person shall leave the same.

Article 4. The officer of customs detaining any ship as aforesaid, shall forthwith give notice thereof, and of the cause of such detention, to the sanitary authority of the place to which the ship shall be bound, or where the ship shall be about to call.

Article 5. Such detention by the officer of customs shall cease as soon as the ship shall have been duly visited and examined by the medical officer of health; or if the ship shall, upon such examination, be found to be infected with cholera, as soon as the same shall be moored or anchored in pursuance of Article 10 of this Order.

Provided, that if the examination be not commenced within twelve hours after notice, given as aforesaid, the ship shall, on the expiration of the said twelve hours, be released from detention.

II. Regulations as to Sanitary Authorities.

Article 6. Every port sanitary authority, and every other sanitary authority within whose district persons are likely to be landed from any ship coming foreign shall, as speedily as practicable, with the approval of the chief officer of customs of the port, fix some place where any ship may be moored or anchored, for the purpose of Article 10; and shall make provision for the reception of cholera patients, and persons suffering from illness removed under Articles 13 and 14. The place to be fixed as aforesaid, where any ship may be moored or anchored for the purpose of Article 10, shall be some place within the jurisdiction or district of the sanitary authority, unless the Local Government Board otherwise consent; in which case the place so fixed shall, for the purposes of this order, be deemed to be within such jurisdiction or district.

Article 7. The sanitary authority, on notice being given to them by an officer of customs, under this Order, shall forthwith cause the ship, in regard to which such notice shall have been given, to be visited and examined by their medical officer of health, for the purpose of ascertaining whether she is infected with cholera.

Article 8. The medical officer of health, if he have reason to believe that any ship coming or being within the jurisdiction or district of the sanitary authority, whether examined by the officer of customs or not, is infected with cholera, shall, or if she have come from a place infected with cholera, may visit and examine such ship for the purpose of ascertaining whether she is so infected; and the master of such ship shall permit the same to be so visited and examined.

Article 9. If the medical officer of health, on making such examination as aforesaid (whether under Article 7 or under Article 8), shall be of opinion that the ship is infected, he shall forthwith give a certificate in duplicate, in the following form, or to the like effect, and shall deliver one copy to the master, and retain the other copy or transmit it to the sanitary authority. He shall also give to the Local Government Board information as to the arrival of the ship, and such other particulars as that Board may require.

Certificate.

________ *day of* __________, 189 ,

____________Sanitary Authority of____________

I hereby certify that I have examined the ship____________ of____________ now lying in the port of____________ (*or detained at* ____________), and that I find that she is infected with Cholera.

____

Medical Officer of Health (or medical practitioner appointed by the sanitary authority).

Article 10. The master of any ship so certified to be infected with cholera, shall thereupon moor or anchor her at the place fixed for that purpose under Article 6, and she shall remain there until the requirements of this order have been duly fulfilled.

Article 11. No person shall leave any such ship until the examination hereinafter mentioned shall have been made.

Article 12. The medical officer of health shall, as soon as possible after any such ship has been certified to be infected with cholera, examine every person on board the same, and in the case of any person suffering from cholera or from any illness which the medical officer of health suspects may prove to be cholera, shall certify accordingly; and any person who shall not be so certified by him shall be permitted to land immediately on giving to the medical officer of health his name and place of destination, stating, where practicable, his address at such place.

The name and address of any such person shall forthwith be given by the medical officer of health to the clerk to the sanitary authority, and such clerk shall thereupon transmit the same to the local authority of the district in which the place of destination of such person is situate.

Article 13. Every person certified by the medical officer of health to be suffering from cholera shall be removed, if his condition admit of it, to some hospital or other suitable place appointed for that purpose by the sanitary authority; and no person so removed shall leave such hospital or place until the medical officer of health shall have certified that such person is free from the said disease.

If any person suffering from cholera cannot be removed, the ship shall remain subject, for the purposes of this order, to the control of the medical officer of health; and the infected person shall not be removed from or leave the ship, except with the consent in writing of the medical officer of health.

Article 14. Any person certified by the medical officer of health to be suffering from any illness, which such officer suspects may prove to be cholera, may either be detained on board the ship for any period not exceeding two days, or be taken to some hospital or other suitable place appointed for that purpose by the sanitary authority, and detained there for a like period, in order that it may be ascertained whether the illness is or is not cholera.

Any such person who, while so detained, shall be certified by the medical officer of health to be suffering from cholera, shall be dealt with as provided by Article 13 of this order.

Article 15. The medical officer of health shall, in the case of every ship certified to be infected, give directions, and take such steps as may appear to him to be necessary for preventing the spread of

infection, and the master of the said ship shall forthwith carry into execution such directions as shall be so given to him.

Article 16. In the event of any death from cholera taking place on board such ship while detained under Article 10, the master shall, as directed by the sanitary authority or the medical officer of health, either cause the dead body to be taken out to sea and committed to the deep, properly loaded to prevent its rising, or shall deliver it into the charge of the said authority for interment; and the authority shall thereupon have the same interred.

Article 17. The master shall cause any articles that may have been soiled with cholera discharges to be destroyed, and the clothing and bedding and other articles of personal use, likely to retain infection, which have been used by any person who may have suffered from cholera on board such ship, or who having left such ship shall have suffered from cholera during the stay of such ship in any port, to be disinfected or (if necessary) destroyed; and if the master shall have neglected to do so before the ship arrives in port, he shall forthwith, upon the direction of the sanitary authority or the medical officer of health, cause the same to be disinfected or destroyed, as the case may require; and if the said master neglect to comply with such direction within a reasonable time, the authority shall cause the same to be carried into execution.

Article 18. The master shall cause the ship to be disinfected, and every article therein, other than those last described, which may probably be infected with cholera, to be disinfected or destroyed, according to the directions of the medical officer of health.

Article 19. The master of every ship infected with cholera shall, when within three miles of the coast, cause to be hoisted the commercial code signal Q, being a yellow flag, under the National Ensign, and shall keep the same displayed between sunrise and sunset.

II.—THE SALE OF FOOD AND DRUGS ACT, 1875

This Act defines *food* as including every article used as food or drink by man other than drugs or water, and *drug* as including medicine for external or internal use (Section 2). Under Section 3 it is enacted that no article of food shall be mixed or treated so as to render the article injurious to health with the intent that the same may be sold in that state; while Section 4 enacts similar provisions in respect to any drug, and for an infringement of either of these sections a penalty not to exceed fifty pounds for a first offence is incurred. Section 5 provides that there shall be no penalty incurred if the accused can show that he was unaware of

the adulteration. Section 6 provides that no person shall sell to the prejudice of the purchaser any article of food or drug which is not of the nature, quality, and substance asked for, under a penalty, but no offence shall be deemed to be committed in the following cases :—(1) Where any matter or ingredient not injurious to health has been added to the food or drug because the same is required for the preparation or production thereof as an article in a state fit for carriage or consumption, and not with intent to increase the bulk, or in any way defraud, or conceal the inferior quality thereof; (2) where the food or drug is a proprietary medicine, or is the subject of a patent, and is supplied according to the patent; (3) where the food or drug is properly compounded; and (4) where the food or drug is unavoidably mixed with any extraneous matter in the process of collection or preparation. Section 7 enacts that no person shall sell any compound, drug, or article of food which is not composed of ingredients in accordance with the demand of the purchaser under a penalty; but, according to Section 8, no offence is committed in respect of the sale of a drug or article of food mixed with an ingredient not injurious to health if it is labelled as mixed at the time of sale. Section 9 provides that no person shall abstract from an article of food any part of it, so as to affect injuriously its quality, substance, or nature; and no person shall sell any article so altered without making disclosure of the alteration under a penalty. Section 10 refers to the appointment of public analysts. Section 12 provides that any person shall be entitled to have any drug or article of food purchased by him in his own sanitary district analysed by the analyst for that district at a fee not exceeding 10s. 6d., and to receive a certificate with the result of the analysis. Section 13 enacts that the officer appointed by the local authority with the execution of the Act may procure samples of food and drugs and submit them to the public analyst. Any person purchasing an article for analysis shall, upon the completion of the purchase, forthwith notify to the seller his intention to have it analysed by the public analyst; and shall offer to divide it into three parts, to be then and there separated, and each part to be marked or sealed or fastened up, and shall, if required to do so, proceed accordingly, and shall deliver one of the parts to the seller, another he shall retain for comparison, and deliver the third to the analyst (Section 14). According to Section 15, if the seller do not accept the offer of division, the analyst must divide the article into two parts, and seal up and deliver one of them to the purchaser. Section 16 provides that samples may be sent to the analyst by post in a registered letter, if his residence is two miles from that of the purchaser.

[Here it should be noted that there is an important amendment of this section contained in Section 2 of the Post-Office Act of 1891, under which the words "registered parcel" are to be substituted for the words "registered letter," so that samples can now be forwarded to the public analyst by parcel post.]

Section 17 enacts that any person refusing to sell to an officer of the local authority any article of food or drug on sale by retail, the price being tendered, and the quantity demanded not being greater than is reasonably requisite, is liable to a penalty not exceeding ten pounds. The justices before whom a case is heard may, at the request of either party, cause any article of food and drug to be sent to the Commissioners of Inland Revenue for analysis by the chemists of their department at Government House (Section 22). It is provided by Section 24 that, as regards all the exemptions under Section 6, the *onus* of proof rests with the defendant; while Section 25 provides that in any prosecution under this Act the defendant is to be discharged if he proves to the satisfaction of the Court (1) that he bought the article as being the same in nature, substance, and quality with that demanded by the purchaser, and with a written warrant to that effect; (2) that at the time of sale he had no reason to believe it to be otherwise; and (3) that he sold it in the same state as he purchased it.

This Act was amended by the *Sale of Food and Drugs Amendment Act of* 1879, in order to settle some disputed points which had arisen in carrying out the 1875 Act.

Section 2 provides that it shall be no defence to allege that the purchaser is not prejudiced by the sale of an adulterated article, on the ground that he bought it for analysis only; or to allege that the article in question, though defective in nature, substance, or quality, was not defective in all three respects. According to Section 3, the officer charged with the execution of the Act may procure, at the place of delivery, a sample of milk in course of delivery to the purchaser or consignee in pursuance of any contract, and may submit the sample to the public analyst; while Section 4 renders the seller, or his representative, liable to a penalty if he refuses to allow a sufficient sample to be taken. Section 6 provides that as regards spirits not adulterated otherwise than by admixture of water, it is a good defence to prove that the admixture has not reduced the spirit more than 25 degrees under proof for brandy, whiskey, or rum, or 35 degrees under proof for gin.

III.—THE RIVERS POLLUTION PREVENTION ACT, 1876

This Act deals with four different kinds of pollution, viz. (1) solid matters, (2) sewage, (3) trade effluents, (4) mining effluents.

(1) No solid refuse or waste matter of any kind must be put into any stream so as to obstruct its flow or pollute its waters (Section 2).

(2) No solid or liquid sewage matter must be discharged into any stream ; but as regards conditions existing prior to the passing of the Act, no offence is committed under the Act if it can be proved that the best practical and available means have been adopted to purify the sewage before it enters the stream (Section 3).

(3) No poisonous, noxious, or polluting liquid proceeding from any factory or manufacturing process must be passed into any stream, but the same saving clause as above is repeated in respect to conditions existing prior to 1876 (Section 4).

(4) No solid matter from mines must be put into any stream to obstruct its flow ; nor any poisonous, noxious, or polluting solid or liquid matter be passed into any stream, other than water which has been raised or drained from such mine (Section 5).

According to Section 6, proceedings cannot be taken against any person under this Act save by a sanitary authority, nor can the authority proceed without the consent of the Local Government Board. On complaint of any person, however, the Board may direct the sanitary authority to proceed if satisfied that there is sufficient cause, but in giving or withholding their consent, the Board shall have regard to the industrial interests involved, and the circumstances and requirements of the locality; nor shall the Board give their consent to proceedings in respect to any manufacturing industry, unless they are satisfied, after due inquiry, that means for rendering harmless the effluents from the processes of such manufactures are reasonably practicable and available, and that no material injury will be inflicted on the industry by such proceedings.

Section 7 enacts that every sanitary authority must give facilities for admitting trade effluents into their sewers, unless such effluents would injure the sewers, or interfere with the disposal of the sewage, or would, from their temperature or otherwise, prove injurious from a sanitary point of view ; or unless the sewers are only sufficient for the requirements of their district, or where such

facilities would interfere with any order of a competent court of jurisdiction respecting the sewage of such authority.

With regard to the standard of effluents admissible into rivers recommended by the Rivers Pollution Commission, see page 356.

IV.—THE CANAL BOATS ACT, 1877

The expression "canal" includes any river, inland navigation, lake, or water within the body of a county whether it is or not within the ebb or flow of the tide. "Canal boat" means any vessel, however propelled, which is used for the conveyance of goods along a canal, and which is not a ship duly registered under the Merchant Shipping Act.

Section 1 provides that no canal boat shall be occupied as a dwelling unless it be registered, and it can only be used by the number of persons of the age and sex for which it is registered under a penalty. Under Section 2 the Local Government Board shall make regulations, which they may revoke or alter from time to time—(1) for registration; (2) for marking, lettering, or numbering; (3) for fixing the number, age, and sex of persons who may be allowed to use a boat; (4) for promoting cleanliness; and (5) for the prevention of disease. Section 3 provides that upon registration two certificates shall be given to the owner, one of which must be carried by the master, identifying the owner and the boat, and stating the place to which the boat belongs, and the number, age, and sex of the persons allowed to dwell in it. Every registered boat must have conspicuously painted or affixed upon it the word "registered," the name of the place to which it belongs, and the registered number. Section 4 empowers sanitary authorities, on receiving information of the existence of a case of infectious disease on board a boat to exercise all the powers vested in them by the Public Health Act, 1875, for the prevention of the spread of disease in dwellings, removal of the patients if practicable and necessary, and disinfection; and for all these purposes the boat may be detained until after it has been disinfected. Section 5 gives power of entry to the officer of the sanitary authority between the hours of 6 A.M. and 9 P.M., if he has reason to suspect any contravention of the Act, or that any one on board is suffering from infectious disease, or for purposes of inspection. The master of the boat is bound to produce his certificate (if any) and to afford facilities to the officer for entry and departure from the boat. A refusal to

comply with the requisition of the officer shall be deemed to be an obstruction, and renders the person so obstructing liable to a penalty. Section 6 provides for the education of children on board canal boats; while Section 7 enacts that the registration authority must be a sanitary authority whose district abuts on the canal on which such boat is intended or accustomed to ply, or one or more of such authorities as the Local Government Board may from time to time prescribe by regulation. The boat must also be registered as belonging to some place in the said district, and which is also either a school district or part of a school district.

The regulations, which the Local Government Board, directed by Section 2, issued in 1878, are briefly as follows:—There must be at least one cabin, which must be kept dry, clean, weather-proof, and in good repair. An after cabin to be used as a dwelling must contain not less than 180 cubic feet, and a fore-cabin 80 cubic feet of free air space. Every such cabin must be ventilated independently of the door, and must afford adequate sleeping accommodation. One cabin must contain a stove and chimney, and the boat must be furnished with suitable storage for at least three gallons of drinking water. If the boat is intended to carry offensive cargoes, the hold must be separated from any inhabited cabin by a double bulkhead, with an interspace of 4 inches, and the bulkhead next the cargo must be water-tight. For each person over twelve years of age not less than 60 cubic feet of free air-space shall be allowed, and not less than 40 feet for each child under that age. In fly-boats worked by shifts, a cabin occupied by two persons at the same time must have at least 180 cubic feet free air-space. No male over fourteen years of age, or female over twelve, must sleep in the same cabin with a married couple, nor must a male over fourteen or a female over twelve occupy the same sleeping-cabin at the same time. Exceptions, however, are made in respect to married couples, and there are also reservations in respect to boats built prior to the passing of the Act. The interior of any cabin must be kept clean and painted every three years, and bilge water must be pumped out daily. The master of the boat is bound to notify forthwith any case of infectious disease occurring in the boat to the sanitary authority of the district through which the boat may be passing at the time, and also to the sanitary authority of the place of destination. He must also inform the owner, who is required to notify to the sanitary authority of the place to which the boat belongs. If the sanitary authority deems it necessary to detain the boat for purposes of disinfection, they must furnish a certificate to the master that the boat has been cleansed and disinfected.

The *Canal Boats Act* of 1884 amends the Act of 1877—

Section 1 nullifies any certificate of registration when any structural alterations are carried out which affect the conditions under which the certificate was granted; Section 2 imposes a penalty for contravention of regulations; and Section 3 makes it incumbent upon every authority through whose district any canal or canals pass to enforce the provisions of the Act and the above regulations, and to make a report to the Local Government Board within twenty-one days after the close of each year, on the steps taken to give effect to the Act and regulations. Under Section 4 the Local Government Board is required to present a report annually to both Houses of Parliament as to the execution of both Acts and observance of regulations, and to cause inquiries to be made from time to time by an inspector or inspectors appointed for that purpose, who have similar powers to poor law inspectors as to the production of papers, examination of witnesses, etc., and have full powers of entry on all boats. Sections 5 and 6 refer to the education of children on canal boats, and Section 7 enjoins that every boat shall be conspicuously lettered, marked, or numbered, either on both sides of the boat, or on the stern.

V.—THE PUBLIC HEALTH (WATER) ACT, 1878

This Act applies for the most part to *rural* sanitary authorities, but Section 11 empowers the Local Government Board to invest any *urban* sanitary with all or any of the powers of the Act for the whole or any part of their district. Section 3 enacts that it shall be the duty of every *rural* authority to see that every occupied dwelling-house within their district has within a reasonable distance a sufficient supply of wholesome water. If the medical officer of health or sanitary inspector reports that any such dwelling-house has not such a supply within a reasonable distance, and the authority are of opinion that such supply can be provided at a reasonable cost, the interest on which, at five per cent, shall not exceed twopence per week, or at such other cost, the interest on which at five per cent shall not exceed threepence per week, as the Local Government Board on application by the authority shall deem to be reasonable, and are further of opinion that the expense of the supply ought to be paid by the owner or defrayed as private improvement expenses, then proceedings may be taken as follows:—(1) The authority may serve notice on the owner of the house requiring him within a time specified in the notice and not exceeding six months to provide such supply, and do all such works as

may be deemed necessary for that purpose. (2) If the notice is not complied with within the time specified, the authority may issue a second notice informing the owner that if the requirements of the first notice are not complied with within one month, the authority will themselves provide such supply, and that the expense will be payable by him, or as a private improvement expense. (3) If at the expiration of one month after the date of the second service, the requirements of the first notice are not complied with, the authority may themselves provide the supply, and for that purpose shall have full powers of entry on premises under Sections 102 and 103 of the Public Health Act, 1875 (see *ante*, p. 620). (4) Any expenses incurred by the authority in providing such supply may be recovered in a summary manner from the owner of the house, or may, at the option of the authority, be declared by their order to be private improvement expenses. (5) Where the owners of two or more houses have failed to comply with the notices, and the authority might under this Act execute the necessary works for providing a water-supply for each, the authority may, if it appears to them desirable, and no greater expense would be incurred, provide a joint supply for those houses and apportion the expenses.

[Here it may be noted that if the owners of adjoining houses fail to provide a proper supply for their several properties, the authority has power to furnish such supply and do all necessary works, and this is sometimes the most economical way of meeting the difficulty.]

Section 3 further enacts that nothing in this section relieves the authority from the duty imposed upon them by the Public Health Act, 1875, of providing their district, or any contributory place or part of their district, with a supply of water, when danger arises to the health of the inhabitants either from unwholesomeness or insufficiency. Section 4 gives an owner the right of appeal on the following grounds :—(1) That the supply is not required ; (2) that the time specified in the notice is insufficient ; (3) that it is impracticable to provide the supply at a reasonable cost ; (4) that the authority ought themselves to provide a supply for the district or contributory place in which the house is situate, or render the existing supply wholesome ; or (5) that the whole or part of the expenses of providing the supply, or making the existing supply wholesome, ought to be a charge on the district or contributory place. If the owner within twenty-one days of the service of the

second notice addresses a memorial to the authority stating his objections, the authority cannot themselves provide the supply until they have been authorised by a court of summary jurisdiction or the Local Government Board. If the objections do not include either the grounds (4) or (5), the authority may apply to the court for an order authorising them to proceed, and thereupon the court shall summon the owner, and if satisfied that the objections are not well founded, shall make an order authorising the authority to proceed with the works in the event of their not being executed by the owner within a time limited by the order. If the objections stated in the memorial are, or include (4) or (5), or either of them, the authority is bound to forward a copy to the Local Government Board, who may either cancel the requirement of the authority or confirm the same, with or without modifications. If the Board confirm, they shall issue an order authorising the authority, subject to such modifications as they may prescribe, to execute the works, if not executed by the owner within the time specified ; and any such order may, if the Board think it equitable, apportion the expense between the owner and the authority, or between the owner and any other person or persons interested. If the Board cancel the requirement on the grounds that the authority ought themselves to provide a supply for the district or contributory place in which the house is situated, or to render the supply wholesome, the memorial shall be deemed to be a complaint of default made to the Board against the authority under Section 299 of the Public Health Act, 1875 (see *ante*, p. 636).

Section 5 provides that where the expenses of providing a joint supply for two or more houses are apportioned by the authority, notice of such apportionment shall be given to each of the owners, and if any owner objects he may within twenty-one days apply to a justice, and thereupon the justice may summon the authority and also the other owners to show cause before a court of summary jurisdiction why the apportionment should not be varied, and the court may either dismiss the application or make such order, varying the apportionment as may appear reasonable.

Section 6 renders it unlawful for the owner of any new dwelling-house, or of any dwelling-house which may be pulled down to or below the ground floor and rebuilt, to occupy the same, or allow it to be occupied unless he has obtained from the authority a certificate on the report of the medical officer of health or sanitary inspector that there is provided a sufficient supply of wholesome water within a reasonable distance. If the authority refuses a certificate the owner may apply to a court of summary jurisdiction for an order to occupy, and thereupon the court shall summon the

authority, and if satisfied, after hearing the case, that a certificate ought to have been granted, they may make an order authorising occupation. Any owner who contravenes this section is liable to a penalty.

Section 7 renders it incumbent on every *rural* authority to take steps from time to time, either through their officers or otherwise, to ascertain the condition of the water-supply of their district, and for this purpose have full powers of entry on premises under Sections 102 and 103 of the Public Health Act, 1875. Section 8 provides that if a local authority makes application to the Local Government Board under Section 62 of the Public Health Act (see *ante*, p. 612) to determine what is a reasonable cost, the Board may, by order, fix a scale of charges for the whole or any part of the district. Section 9 enacts that when a *rural* authority has provided a stand-pipe or pipes for the supply of any portion of their district, they may recover water-rates from the owner or occupier of any dwelling-house within 200 feet of any such stand-pipe, provided that no rate shall be recoverable from the owner or occupier of any dwelling within that distance which is provided with a proper supply, and the inmates do not use the public supply. Section 10 provides that where a sanitary authority supply water in an *urban* district or in any contributory place, and an application is made to them by ten ratepayers in such *urban* district, or five in such contributory place, to charge water-rates or rents in respect of the water so supplied, it becomes incumbent on the authority to exercise the powers vested in them to charge water-rates.

VI.—THE BATHS AND WASH-HOUSES ACTS

The Baths and Wash-houses' Act of 1846 empowered every borough and populous parish in England to provide public baths and wash-houses for the use of the inhabitants subject to the approval of the Secretary of State, and to make regulations for the same. The Amending Act of 1847 fixed a definite scale of charges, and the Local Government Act of 1871 transferred the functions of the Secretary of State in respect to both Acts to the Local Government Board. Section 10 of the Public Health Act, 1875, now gives power to urban authorities to adopt and act under those statutes to the exclusion of any other

authority. Another amending Act, namely The Baths and Wash-houses Act of 1878, extended all the provisions of the two previous Acts to covered swimming baths, as well as to baths, wash-houses, and open bathing places.

By Section 5 of this Act power is given to an urban authority to close any covered or open swimming-bath for a period during each year not exceeding five months, from the beginning of November to the end of March, and they may either keep the same closed or use it for a gymnasium, or for any other purpose of healthful recreation.

VII.—THE FACTORY AND WORKSHOPS ACT, 1878

Section 3 requires that every factory and workshop shall be kept in a cleanly state and free from effluvia arising from any drain, privy, or other nuisance. It shall not be so overcrowded as to be injurious to health, and shall be ventilated in such a manner as to render harmless, so far as practicable, all gases, vapours, dust, or other impurities generated in the process of manufacture which may be injurious to health. Section 4 empowers the factory inspector to give notice to the sanitary authority of any nuisance or default in relation to any drain, water-closet, earth-closet, privy, ash-pit, or water-supply, punishable or remediable under the Public Health Act, but not under this Act, and for this purpose may take with him into a factory or workshop any officer of the sanitary authority. Section 33 provides that all inside walls, ceilings, passages, and staircases, if not painted or varnished once at least every seven years, must be lime-washed once at least every fourteen months, and if painted or varnished must be washed with hot water and soap every fourteen months.

Under Section 34 bakehouses in towns containing over 5000 inhabitants shall have all the inside walls, ceilings, passages, and staircases either painted or varnished or lime-washed, or partly painted or varnished and partly lime-washed; if painted or varnished they must have three coats of paint or varnish, and be washed with hot water and soap every six months, and where lime-washed the lime-washing shall also be renewed every six months. Section 35 further provides that in towns or places containing over 5000 inhabitants, no place on the same level as a bakehouse shall be used as a sleeping-place, unless it is effectually separated from the bakehouse by a partition extending from floor to ceiling, and unless it has an external window 9 feet square, half of which is made to open.

Section 61 makes special exception for domestic and certain other factories other than bakehouses, wherein children and other young persons are employed, provided that the occupier has given notice to the factory inspector of his intention to exclude such persons; while Section 63 empowers the Secretary of State to make special sanitary regulations for the protection of the health of any child, young person, or woman employed over-time or at night.

The *Factory and Workshop Act of* 1883 amends this Act more particularly in respect to white lead factories and bakehouses, and transfers the control of retail bakehouses to sanitary authorities:—

Section 15 declares it to be unlawful to let or occupy as a bakehouse any room or place which was not so let or occupied before 1st June 1883, unless the following regulations are complied with:—(1) no water-closet, earth-closet, privy, or ash-pit shall be within or communicate directly with the bakehouse; (2) any cistern supplying water to the bakehouse must be separate from any cistern supplying a water-closet; (3) no drain or pipe carrying off sewage shall have an opening within the bakehouse. Any one contravening these regulations is liable to a penalty. Section 16 renders the occupier of a bakehouse liable to a penalty which is in such an insanitary condition as to be unfit for use or occupation as a bakehouse, whether the same was or was not used as such before the passing of the Act. Section 17 enacts that in respect to every retail bakehouse the provisions of this part of this Act, and of Sections 3, 33, 34, and 35 of the 1878, which relate to cleanliness, ventilation, overcrowding, and other sanitary conditions, shall be enforced by the local authority, and for the purposes of this section the medical officer of health shall have all the powers of a factory inspector as to entry, inspection, and taking legal proceedings.

The *Factory and Workshops Act,* 1891, which came in force on 1st January 1892, amends the two previous Acts. The object of this Act is to bring all factories and workshops, including laundries (except domestic "workshops," which are left to be governed by the general laws relating to public health) up to the same level in respect to ventilation, overcrowding, cleanliness, and other sanitary requirements; to secure proper provision against fire, the proper fencing of machinery; and to regulate

the hours and conditions of employment in certain cases. The most important provisions which it contains, so far as it affects sanitary authorities, are those which relate to workshops, the sanitary regulation of which it places under the control of sanitary authorities instead of that of the factory inspectors. In respect to overcrowding, it may be noted that although no minimum amount of cubic space has been laid down in any of the Acts, it is generally conceded that at least 250 cubic feet should be allowed for each worker or *employé*. The following circular, issued by the Local Government Board to sanitary authorities in September 1891, will best explain the various amendments and provisions of the new Act:—

"It is provided by Section 91 of the Public Health Act, 1875, as amended by Section 107 of the Factory and Workshop Act, 1878, that any factory, workshop, or workplace not kept in a cleanly state, or not ventilated in such a manner as to render harmless, as far as practicable, any gases, dust, or other impurities generated in the course of the work carried on therein that are a nuisance or injurious to health, or so overcrowded while work is carried on as to be dangerous or injurious to the health of those employed therein, shall be deemed to be a nuisance liable to be dealt with summarily in manner provided by the Public Health Act. (See *ante*, page 616, Sub-section 6.)

"Section 101 of the Factory and Workshop Act, 1878, however, directed that this provision should not apply to a factory or workshop subject to the provisions of that Act relating to cleanliness, ventilation, and overcrowding.

"The words 'or workshop' in the last-mentioned section are repealed by Section 39 of the new Act, and the effect of this is to make the provision in Section 91 of the Public Health Act above referred to applicable to workshops generally, instead of only to those not now subject to the Factory and Workshop Act, 1878; and it will be the duty of the sanitary authority to enforce that provision accordingly.

"The new Act also provides that Sections 3 and 33 of the Factory and Workshop Act, 1878, which relate to cleanliness, ventilation, and overcrowding in, and lime-washing of, factories and workshops, shall cease to apply to workshops. (Sections 3 (1) and 39.) These matters must, therefore, now be dealt with under

the Public Health Act or under the powers conferred by Section 4 of the new Act.

"That section provides that every workshop as defined by the Factory and Workshop Act, 1878, including any workshop conducted on the system of not employing any child, young person, or woman therein, and every workplace within the meaning of the Public Health Act, 1875, shall be kept free from effluvia arising from any drain, water-closet, earth-closet, privy, urinal, or other nuisance, and unless it is so kept it is to be deemed to be a nuisance liable to be dealt with summarily under the law relating to public health. (Sub-section (1).)

"The definition of 'workshop' in Section 93 of the Act of 1878, is too lengthy to be inserted here, but one point in connection with it may be mentioned. The section directs that a place solely used as a dwelling shall not be deemed to form part of a workshop for the purposes of the Act. By Section 31 of the new Act, in lieu of this, it is provided that a room solely used for the purpose of sleeping therein shall not be deemed to form part of a workshop for those purposes.

"Section 4 also provides that where, on the certificate of a medical officer of health or inspector of nuisances, it appears to the sanitary authority that the lime-washing, cleansing, or purifying of a workshop, or of any part of it, is necessary for the health of the persons employed therein, the sanitary authority shall give notice to the owner or occupier, requiring him to do the work (Sub-section (2)); and that if he fails to comply with the notice within the time specified therein, he shall be liable to a fine not exceeding 10s. for every day during which he continues to make default, and the sanitary authority may, if they think fit, do the work themselves, and may recover from him in a summary manner the expenses incurred by them in so doing. (Sub-section (3).)

"For the purpose of their duties with respect to workshops, the sanitary authority and their officers, without prejudice to their other powers, are to have all such powers of entry, inspection, taking legal proceedings, or otherwise, as an inspector of factories has under the Act of 1878. (Section 3 (2).)

"As regards these powers, attention may be called to Part III. of the Act of 1878, and especially to Section 68. It has hitherto been necessary, under Section 69 of that Act, that in certain cases the inspector of factories should obtain authority from a Secretary of State, or a warrant of justices, before entering a workshop, but it is now expressly provided by the new Act that the powers of entry conferred by Section 68 of the Act of 1878 on an inspector of factories may be exercised without the authority or warrant

required in certain cases by Section 69, and the latter section is repealed. (Sections 25 and 39.)

"The powers of the sanitary authority under Section 68 of the Act of 1878 will be in addition to those which they now possess under Section 102 of the Public Health Act, 1875. (See *ante*, p. 620).

"If any child, young person, or woman is employed in a workshop, and the medical officer of the sanitary authority becomes aware of it, Section 3 (3) of the new Act requires him forthwith to give notice of the fact to the inspector of factories for the district. This provision should be brought under the notice of the medical officer of health by the sanitary authority. By Section 96 of the Act of 1878 the term 'child' is defined as meaning a person under the age of 14 years, a 'young person' as meaning a person of the age of 14 years and under the age of 18 years, and a 'woman' as a woman of 18 years of age or upwards.

"Section 4 of the Factory and Workshop Act, 1878, provides that where it appears to an inspector of factories that any act or default in relation to any drain, water-closet, earth-closet, privy, ash-pit, water-supply, nuisance, or other matter in a factory or workshop is punishable or remediable under the law relating to public health, but not under that Act, the inspector shall give notice to the sanitary authority, and that on such notice being given it shall be the duty of the sanitary authority to make such inquiry and take such action as may be proper for the enforcement of the law. For the purposes of the section, the inspector of factories may take with him into the factory or workshop a medical officer of health, inspector of nuisances, or other officer of the sanitary authority. The new Act will apply this enactment to workshops conducted on the system of not employing any child, young person, or woman therein, and also to laundries. (Section 2 (1).)

"The Act of 1891 further provides that where an inspector of factories has given notice to the sanitary authority, under Section 4 of the Act of 1878, as amended, and proceedings are not taken within a reasonable time for punishing or remedying the act, neglect, or default referred to in the notice, the inspector may take the like proceedings for this purpose as the sanitary authority might have taken. He will be entitled to recover from the sanitary authority all such expenses as he may incur and are not recovered from any other person, and have not been incurred in any unsuccessful proceedings. (Section 2 (2).)

"By Section 1 of the new Act the Secretary of State is empowered, in cases where he is satisfied that the provisions of the law relating to public health as to effluvia arising from drains,

privies, or other nuisances, or with respect to cleanliness, ventilation, overcrowding, or lime-washing, are not observed in workshops (including workshops conducted on the system of not employing in them any child, young person, or woman) or laundries, by order to direct an inspector or inspectors of factories to take, during the period mentioned in the order, such steps as appear necessary or proper for enforcing those provisions. An inspector so authorised will have similar power of taking proceedings and of recovering the expenses from the sanitary authority to those possessed by an inspector under the provisions of Section 2 (2) of the Act, which are mentioned above. (Section 1 (2).) It will be observed that this section applies to laundries as well as to workshops.

"Section 75 of the Factory and Workshop Act, 1878 (which requires notice to be given to an inspector of factories of the occupation of a factory), is to apply also in the case of a workshop; and on receiving notice of the occupation of a workshop, the inspector of factories is to forthwith forward the notice to the sanitary authority of the district in which the workshop is situate. (Section 26.)

"The occupier of every factory and workshop (including any workshop conducted on the system of not employing any child, young person, or woman therein), and every contractor employed by any such occupier in the business of the factory or workshop, must, if required to do so by an order of the Secretary of State, keep in a form and with particulars prescribed by the Secretary of State lists showing the names of all persons directly employed by him, either as workman or as contractor, in the business of the factory or workshop outside the factory or workshop, and the places where they are employed, and the list is to be open to inspection by any officer of the sanitary authority. If this section is contravened the occupier or contractor will be liable to a fine not exceeding 40 shillings. (Section 27.)

"Section 7 of the new Act relates to the provision of means of escape from factories in case of fire. It requires with respect to every factory of which the construction is commenced after the 1st of January next, and in which more than 40 persons are employed, that a certificate shall be obtained from the sanitary authority stating that the factory is provided, on the storeys above the ground-floor, with such means of escape in case of fire for the persons employed therein as can reasonably be required under the circumstances of the case. The section makes it the duty of the sanitary authority to examine every such factory, and on being satisfied that the factory is so provided they must give the required certificate. (Sub-section (1).)

"As regards all factories which are already in existence, or which may be begun to be erected before the 1st of January next, and in which more than 40 persons are employed, the section imposes upon the sanitary authority the duty as soon as may be after the passing of the Act, and afterwards from time to time, of ascertaining whether all such factories within their district are provided with the means of escape in the case of fire already referred to, and, if not, of serving on the owner within the meaning of the Public Health Act, 1875 (see Section 4 of that Act), a notice in writing specifying the measures necessary for providing such means, and requiring him to carry them out before a specified date. The owner will thereupon, notwithstanding any agreement with the occupier, have power to take the steps necessary for complying with these requirements, and unless they are duly complied with, the owner will be liable to a fine not exceeding £1 for every day that the non-compliance continues. In the event of a difference of opinion arising between the owner and the sanitary authority, it may be referred to arbitration. The arbitration is to be conducted according to the rules contained in the First Schedule to the Act, except that the parties to the arbitration will be the sanitary authority on the one hand, and the owner on the other. The award on the arbitration will be binding on the parties to it. (Sub-section (2).)

"The expenses of a *rural* sanitary authority in the execution of this section are to be defrayed as special expenses, and to be charged to the contributory place in which the factory is situate. (Sub-section (3).) The sanitary authority will not be empowered to charge fees for certificates granted under the section.

"The new Act also amends the provisions of the Factory and Workshop Act, 1883, relating to retail bakehouses. Under Section 36 those provisions will cease to apply to a place which is a factory within the meaning of the Factory and Workshop Act, 1878, and consequently the duties of the sanitary authority under Section 17 of the Act of 1883 will, after the 1st of January next, apply only to retail bakehouses, as defined by Section 18 of that Act, which are not factories within the definition of the expression 'factory' in Section 93 of the Act of 1878.

"Sub-section (2) of Section 17 of the Act of 1883, relating to notices by the medical officer of health to the inspector of factories of children, young persons, or women being employed in bakehouses, is repealed. (Section 39.)

"The new Act is to be construed as one with the Factory and Workshop Act, 1878. (Section 41.)

"It will be seen that new and important duties will devolve

upon sanitary authorities and their officers and the Board trust that every effort will be used to ensure their being satisfactorily discharged."

VIII.—THE PUBLIC HEALTH (FRUIT PICKERS' LODGINGS) ACT OF 1882

enacts that Section 314 of *The Public Health Act*, 1875, which enables any local authority to make bye-laws for securing the decent lodging and accommodation of persons engaged in hop-picking within the district of such authority shall be deemed to extend to and authorise the making of bye-laws for securing the decent lodging and accommodation of persons engaged in the picking of fruit and vegetables.

IX.—THE MERCHANT SHIPPING (FISHING BOATS) ACT, 1883

empowers local authorities to make bye-laws for the regulation of seamen's lodgings, while the Public Health (Ships) Act, 1885, amends Section 287 of the Public Health Act, 1875 (see *ante*, p. 637), and enables the Local Government Board to permanently constitute a port sanitary authority by an order which will not require confirmation by Parliament. It also amends Section 110 of the same Act (see *ante*, p. 621), so that it shall have effect not only for the purpose of the provisions of that Act relating to nuisances, but also for the purpose of such of the provisions of that Act relating to infectious diseases and hospitals as are referred to in Sections 120, 121, 124, 125, 126, 128, 131, 132, and 133 (see *ante*, p. 626).

X.—THE DAIRIES, COW-SHEDS, AND MILK-SHOPS ORDER OF 1885

was first issued by the Privy Council in pursuance of Section 34 of the Contagious Diseases (Animals) Act of

1878. In 1886 an amending Act was passed transferring the powers of the Privy Council under this section to the Local Government Board, and the execution of the Order to local authorities. An amending Order was thereupon issued by the Board, substituting the Board for the Privy Council in the provisions of the previous Order, and remedying certain omissions as regards penalties. The Order, which extends to England and Wales, and Scotland only, contains the following important provisions:—

Registration of Dairymen and Others

Section 6. (1) It shall not be lawful for any person to carry on in the district of any local authority the trade of cowkeeper, dairyman, or purveyor of milk unless he is registered as such in accordance with this article. (2) Every local authority shall keep a register of persons from time to time carrying on in their district the trade of cow-keepers, dairymen, or purveyors of milk, and shall from time to time revise and correct the register. (3) The local authority shall register every such person, but the fact of such registration shall not be deemed to authorise such person to occupy as a dairy or cow-shed any particular building, or in any way preclude any proceedings being taken against such person for non-compliance with or infringement of any of the provisions of this Order, or any regulation made thereunder. (4) The local authority shall from time to time give public notice of registration being required, and of the mode of registration. (5) A person who carries on the trade of cow-keeper or dairyman for the purpose only of making and selling butter or cheese, or both, and who does not carry on the trade of purveyor of milk, need not be registered. (6) A person who sells milk of his own cows in small quantities to his workmen or neighbours for their accommodation need not, by reason thereof, be registered.

Construction and Water-Supply of New Dairies and Cow-Sheds

Section 7. (1) It shall not be lawful for any . . . cow-keeper or dairyman to begin to occupy as a dairy or cow-shed any building not so occupied at the commencement of this Order . . . until he first makes provision, to the reasonable satisfaction of the local authority, for the lighting and ventilation, including air-space, and the cleansing, drainage, and water-supply of the same. . . . (2) It

shall not be lawful for any such person to begin so to occupy any such building without first giving one month's notice in writing to the local authority of his intention so to do.

Sanitary State of all Dairies and Cow-Sheds

Section 8. It shall not be lawful for any . . . cow-keeper or dairyman to occupy as a dairy or cow-shed any building—whether so occupied at the commencement of this Order or not—if . . . the lighting and ventilation, including air-space, and the cleansing, drainage, and water-supply thereof, are not such as are necessary or proper (*a*) for the health and good condition of the cattle therein; and (*b*) for the cleanliness of milk-vessels used therein for containing milk for sale; and (*c*) for the protection of the milk therein against infection or contamination.

Section 9. It shall not be lawful for any . . . cow-keeper, or dairyman, or purveyor of milk, or occupier of a milk-shop (*a*) to allow any person suffering from a dangerous infectious disorder, or having recently been in contact with a person so suffering, to milk cows or to handle vessels used for containing milk for sale, or in any way to take part or assist in the conduct of the trade . . . so far as regards the production, distribution, or storage of milk; or (*b*) if himself so suffering, or having recently been in contact as aforesaid, to milk cows or handle vessels containing milk for sale, or in any way to take part in the conduct of his trade as far as regards the production, distribution, or storage of milk; until, in each case, all danger therefrom of the communication of infection to the milk or of its contamination has ceased.

Section 10. It shall not be lawful for any person following the trade of cow-keeper, or dairyman, or purveyor of milk, or being the occupier of a milk-store or milk-shop, after the receipt of notice of not less than one month from the local authority calling attention to the provisions of this article, to permit any water-closet, earth-closet, privy, cesspool, or urinal to be within, communicate directly with, or ventilate into, any dairy or any room used as a milk-store or milk-shop.

Section 11. It shall not be lawful for any person following the trade of cow-keeper, or dairyman, or purveyor of milk, or being the occupier of a milk-store or milk-shop, to use a milk-store or milk-shop in his occupation, or permit the same to be used, as a sleeping apartment, or for any purpose incompatible with the proper preservation of the cleanliness of the milk-store or milk-shop, and of the milk-vessels and milk therein, or in any manner likely to cause contamination of the milk therein.

Section 12. It shall not be lawful for any person following the trade of a cow-keeper, or dairyman, or purveyor of milk, to keep any swine in any cow-shed or other building used by him for keeping cows, or in any milk-store or other place used by him for keeping milk for sale.

Regulations of Local Authority

Section 13. A local authority may from time to time make regulations for the following purposes, or any of them :—(*a*) For the inspection of cattle in dairies. (*b*) For prescribing and regulating the lighting, ventilation, cleansing, drainage, and water-supply of dairies and cow-sheds. . . . (*c*) For securing the cleanliness of milk-stores, milk-shops, and of milk-vessels used for containing milk for sale. (*d*) For prescribing precautions to be taken by purveyors of milk and persons selling milk by retail against infection or contamination.

Provisions as to Regulations of Local Authority

Section 14. The following provisions shall apply to regulations made by a local authority under this Order :—(1) Every regulation shall be published by advertisement in a newspaper circulating in the district of the local authority. (2) The local authority shall send to the Local Government Board a copy of every regulation made by them not less than one month before the date named for such regulation to come into force. (3) If at any time the Local Government Board are satisfied, on inquiry, with respect to any regulation, that the same is of too restrictive a character, or otherwise objectionable, they may direct the revocation thereof, and the same shall not come into operation, or shall thereupon cease to operate, as the case may be.

Existence of Disease among Cattle

Section 15. If at any time disease exists among the cattle in a dairy or cow-shed, or other building or place, the milk of a diseased cow therein—(*a*) shall not be mixed with other milk, and (*b*) shall not be sold or used for human food, and (*c*) shall not be sold or used for food of swine, or other animals, unless and until it has been boiled.

XI.—THE MARGARINE ACT, 1887

defines "margarine" as including all substances, whether compounds or otherwise, prepared in imitation of butter, and whether mixed

with butter or not. Every package or parcel of margarine must be so marked in large letters of specified minimum size. All manufactories of margarine must be registered. Any officer authorised to take samples under the Sale of Food and Drugs Act may, without going through the form of purchase provided by that Act (see *ante*, p. 642), but otherwise acting in all respects in accordance with the provisions of the said Act as to dealing with samples, take for the purposes of analysis samples of any butter, or substances purporting to be butter, which are exposed for sale, and are not marked "margarine," as provided by this Act; and such substance not being so marked shall be presumed to be exposed for sale as butter. Every person dealing in margarine, whether wholesale or retail, who is found guilty of an offence under this Act is liable on conviction to a penalty of £20 for the first offence, but there is a saving clause to the effect that the vendor is absolved if he can prove by a written warranty that he purchased the article as butter, and that he sold it in the same state as he received it, believing it to be butter.

XII.—THE HOUSING OF THE WORKING CLASSES ACTS, 1885 and 1890

With the exception of Section 3, which empowers the Treasury to sell the sites of certain metropolitan prisons when they are no longer required, and Sections 7, 8, and 9, and also part of 10, the whole of the 1885 Act is repealed by the 1890 Act. Section 7 enacts that it shall be the duty of every local authority to put in force the powers with which they are invested, so as to secure the proper sanitary condition of all premises within their district. Section 8 empowers every sanitary authority to make bye-laws for lodging-houses or tenements as specified in Section 90 of the Public Health Act, 1879 (see *ante*, p. 615), without the intervention of the Local Government Board.

It may also be noted in passing that, in accordance with the terms of The Customs and Inland Revenue Act, 1890, the medical officer of health must, on request, inspect any houses wholly let in tenements at rents not

exceeding 7s. 6d. weekly, and if satisfied that the accommodation and sanitary arrangements are in every respect satisfactory, his certificate, or that of a medical practitioner appointed by the sanitary authority, will exempt from inhabited house duty.

Section 9 enacts that a tent, van, or similar structure, used for human habitation, which is in such a state as to be a nuisance or injurious to health, or which is so overcrowded as to be injurious to the inmates, whether or not members of the same family, shall be deemed to be a nuisance within the meaning of Section 91 of the Public Health Act, 1875 (see *ante*, p. 615), and the provisions of that Act shall apply accordingly. A local authority is empowered to make bye-laws in regard to tents, vans, and similar structures, and the section further authorises powers of entry between 6 A.M. and 9 P.M. to any duly authorised officer of the local authority, or by a justice of the peace, if such officer has reasonable cause to suspect that there is any contravention of the Act, or of any bye-laws made under it, or that there is in such habitation any person suffering from any dangerous infectious disease. This section applies to the metropolis, but not to any tent, van, etc., used by Her Majesty's naval or military forces. Under Section 10 the provisions of the Public Health Act, 1875, relating to bye-laws made by a sanitary authority shall apply to bye-laws authorised by this Act, and a fine or penalty under any such bye-law may be recovered on summary conviction.

The *Housing of the Working Classes Act*, 1890, with the above exceptions, repeals the whole of the previous Acts relating to labourers' lodging-houses and dwellings, and artisans' dwellings, and is made applicable to London, England and Wales, and Scotland and Ireland. Part I., which supersedes Cross's Acts, deals principally with unhealthy areas, and does not apply to rural districts. Part II., which replaces Torrens's Acts, applies to rural and urban districts, and relates chiefly to unhealthy or obstructive dwellings. Part III., which consolidates the Shaftesbury Acts, applies to all sanitary authorities, and authorises them to provide lodging-houses for the working-classes, subject to the approval of the Local Government

Board, as regards urban authorities, and the County Council as regards rural districts. In the county of London, the administration of this part of the Act is vested in the County Council; while in the City, the administration of all three parts is vested in the Commissioners.

Part I.—Unhealthy Areas

Section 4 enacts that when an official representation is made to the local authority, that within a certain area in their district, (*a*) any houses, courts, or alleys are unfit for human habitation ; or (*b*) that the narrowness, closeness, and bad arrangement, or the bad condition of the streets and houses, or groups of houses within such area, or the want of light, air, ventilation, or proper conveniences, or any other sanitary defects, or one or more of such causes, are dangerous or injurious to the health of the inhabitants, either of the buildings in the said area, or of the neighbouring buildings ; and that the evils connected with such houses, courts, or alleys, and the sanitary defects in such area, cannot be effectually remedied otherwise than by an improvement scheme for the rearrangement and reconstruction of the streets and houses within such area, or of some of such streets or houses, the local authority shall take such representation into their consideration, and if satisfied of the truth thereof, and of the sufficiency of their resources, shall pass a resolution to the effect that such area is an unhealthy area, and that an improvement scheme ought to be made in respect of such area, and after passing such resolution they shall forthwith proceed to make a scheme for the improvement of such area. Provided always, that any number of such areas may be included in one improvement scheme.

Section 5 provides that such official representation shall be made by the medical officer of health, whenever he sees cause to make the same, or if two or more justices, or twelve or more rate-payers make complaint to him of the unhealthiness of any area, he is bound to inspect such area, and report to the local authority. Under Section 6, an improvement scheme may (*a*) exclude any part of the area, or include any neighbouring lands, for making it efficient for sanitary purposes ; (*b*) may provide for widening any existing approaches for purposes of ventilation or health ; (*c*) shall provide such dwelling accommodation, if any, for the working-classes, displaced by the scheme, as is required to comply with the Act ; and (*d*) shall provide for proper sanitary arrangement.

After due publicity has been given to the scheme, by advertising and serving notices, in a manner specified by Section 7, the local authority is required by Section 8 to present a petition to the Secretary of State, if it relates to any part of London, and to the Local Government Board, if it relates to any other urban district, praying that an order may be made to confirm the scheme. The confirming authority shall then direct a local inquiry to be held concerning the sufficiency or otherwise of the scheme, and upon receiving the report, may make a provisional order, which must be confirmed by Act of Parliament as a confirming Act. Such provisional order may approve or modify the scheme, so that no addition be made to the lands proposed to be taken compulsorily. Section 10 requires a local authority, where any official representation is made, to take such representation into consideration, and if they fail to pass any resolution in relation to it, or pass a resolution to the effect that they will not proceed with such scheme, they must send a copy of the official representation, with their reasons for not acting upon it, to the confirming authority, who may direct a local inquiry to be held.

As regards provision of dwelling accommodation for the working-classes displaced by the scheme, Section 11 enacts that in London, accommodation must be provided in or near the area, for the whole number displaced, unless the Order decrees otherwise, by accepting in substitution equally convenient accommodation outside the area, and dispensing with the obligation to provide accommodation to any extent not exceeding one-half. In other parts of the country, such provision is only compulsory if, and to the extent required by the confirming authority after local inquiry. After a confirming Act has been passed, provisions are set forth in several sections for the execution of the scheme, and for the acquisition of land. In assessing the value of property, Section 21 provides that no additional allowance for compulsory purchase is to be made in regard to any unhealthy portion of the area, and the arbitrator may receive evidence, showing that any premises are (1) rented too highly by reason of overcrowding or being used for illegal purposes; (2) that the premises are in such a condition as to be a nuisance or injurious to health; or (3) that the premises are unfit, and cannot reasonably be made fit, for human habitation. In the first case, the compensation is to be based on the rental which would have been obtainable, if the house or premises had not been overcrowded or used for illegal purposes; in the second case, on the amount estimated as the value of the premises, assuming that they had been habitable, after deducting the estimated expense of abating the nuisance or putting them in habitable repair; and in

the third case, on the value of the land and the materials of the buildings only.

Section 16 provides that where complaint is made, by twelve or more ratepayers, to the medical officer of health of the unhealthiness of any area in their district, and he fails to inspect such area or to make an official representation thereon, or has made an official representation to the effect that, in his opinion, the area is not an unhealthy area, such ratepayers may appeal to the confirming authority, who may then appoint a medical practitioner to inspect such area and report to them. This report shall be transmitted to the local authority, and if it states that the area is an unhealthy area, the local authority shall proceed in the same manner as if it were an official representation made to them, and either prepare a scheme, or report the facts to the confirming authority, who may then order a local inquiry to be made. Section 26 provides that, in the case of the illness or unavoidable absence of the medical officer of health, the authority or vestry who appointed him, may, subject to the approval of the confirming authority, appoint a duly qualified medical practitioner, for the period of six months, or any less period, to act as medical officer of health.

Part II.—Unhealthy Dwelling-Houses

Section 30 requires the medical officer of health of every district to represent to the local authority any dwelling-house which appears to him to be unfit for human habitation; while Section 31 makes it incumbent on him, when any four householders complain that a house near which they live is unfit for human habitation, to forthwith inspect the same, and transmit to the authority the said complaint, together with his opinion thereon; but the absence of any such complaint shall not excuse him from inspecting any dwelling-house and making a representation thereon to the authority. If within three months after receiving the said complaint and opinion or representation of the medical officer, the local authority, not being a rural authority or in the county of London, declines or neglects to take proceedings, the householders who signed the complaint may petition the Local Government Board, and, after inquiry, the Board may order the authority to proceed under this part of the Act, and such order shall be binding.

Closing Order and Demolition.—Section 32 provides that proceedings may be taken for closing a dwelling-house whether it be occupied or not.

With regard to the precise mode of proceedings which the provisions of this part of the Act impose on local and confirming authorities, the following extracts from the circular issued by the Local Government may here be fitly quoted:—

"Section 32 expressly declares that it shall be the duty of every sanitary authority to cause to be made from time to time systematic inspection of their district with a view to ascertain whether any dwelling-house therein is in a state so dangerous or injurious to health as to be unfit for human habitation, and if, on the representation of their medical officer of health or any of their officers, or information given to them, any dwelling-house appears to be in such state, to forthwith take the proceedings against the owner or occupier for closing it under Sections 91, 94, 95, and 97 of the Public Health Act, 1875 (see *ante*, pp. 617-619).

"In connection with this section and with the provisions relating to obstructive buildings which are contained in this part of the Act, and to which reference is hereinafter made, it should be stated that Section 52 provides that a representation from the medical officer of health of any county, submitted to the County Council, and forwarded by that Council to the local authority of any district in the county, not being a borough as defined by the Municipal Corporations Act, 1882, shall, for the purpose of this part of the Act, have the like effect as a representation from the medical officer of health of the district.

"Under the Sections of the Public Health Act above referred to, it has hitherto been necessary that the proceedings should be taken with a view to the abatement of a nuisance, and that the works requisite to abate the nuisance complained of should be specified. This, however, will no longer be the case. Section 32 (2) authorises summary proceedings to be taken for the express purpose of causing the dwelling-house to be closed, and appropriate forms are contained in the Fourth Schedule to the Act, which may be used for this purpose.

"The closing order will prohibit the using of the premises for the purpose of human habitation until, in the judgment of the court, they are rendered fit for that purpose. In making it, the court may impose a penalty not exceeding twenty pounds, and may authorise a reasonable allowance to be paid by the sanitary authority to every occupying tenant on account of his expenses in removing from the dwelling-house. The amount of this allowance will be a civil debt due from the owner of the dwelling-house to the sanitary authority, and will be recoverable summarily.

"Where a closing order has been made in respect of any dwelling-house, and has not been determined by a subsequent order, the sanitary authority, if of opinion that the house has not been rendered fit for human habitation, and that the necessary steps are not being taken with all diligence to render it so fit, and that the continuance of any building being, or being part of the dwelling-house, is dangerous or injurious to the health of the public, or of the inhabitants of the neighbouring dwelling-houses, are required by Section 33 to pass a resolution that it is expedient to order the demolition of the building.

"A notice of this resolution must be served on the owner, specifying the time (not less than one month from the service of the notice) and the place appointed by the sanitary authority for the further consideration of the resolution; and any owner will be at liberty to attend and to state his objection to the demolition.

"If upon the consideration of the resolution and the objections the sanitary authority decide that it is expedient so to do, then unless an owner undertakes to execute forthwith the works necessary to render the dwelling-house fit for human habitation, and executes the same within a limited period, the authority are required by the Act to order the demolition of the building.

"Where such an order has been made, any person aggrieved by it may appeal against it to the next court of quarter sessions, but subject to this appeal, and to the power given by Section 47 of the Act to a court of summary jurisdiction to enlarge the time allowed for the demolition of the building, the owner must, within three months after service of the order, proceed to take down and remove the building, and on his default the sanitary authority are required themselves to proceed to do this, and to sell the materials, and after deducting the expenses incident to the taking down and removal of the building, to pay over the balance of money, if any, to the owner.

"Where a building has been taken down and removed under the above provisions, no house or other building or erection may be erected on all or any part of the site of the building which is dangerous or injurious to health. Full power is given to the sanitary authority to enforce compliance with the requirement."

Obstructive Buildings.—Under Section 38, if a medical officer of health finds that any building, though not in itself unfit for human habitation, is so situated that it either—(*a*) stops ventilation or conduces to make other buildings to be unfit for habitation or dangerous or injurious to health; or (*b*) prevents the proper remedying of any nuisance injurious to health or other evils complained of in respect of such other buildings, he must make a

representation to the local authority of the particulars relating to such obstructive building, stating that in his opinion it should be pulled down. Any four or more inhabitant householders, or in respect to rural districts, a county medical officer (Section 52), may make a similar representation. In any case, the local authority must make due inquiry into the facts and as to the cost of acquiring the land and pulling down the building. If they resolve to proceed, they may make an order for the demolition of the obstructive building after giving the owner an opportunity of stating his objections, and subject to appeal to quarter sessions. Where no appeal is made against the order, or is made and either fails or is abandoned, the authority may purchase the site, unless the owner, within one month after notice to purchase, declares that he desires to retain the site, and undertakes either to pull down the building or permits the authority to demolish, in which case he will retain the site and receive compensation. He cannot, however, insist on his entire holding being taken, where part only is proposed to be taken as obstructive, and such part can be severed from the remainder of the house or manufactory without material detriment. The compensation to the owner, and also the amount recoverable from the owners benefited by the demolition, are to be settled by arbitration in cases of dispute. Where the owner desires to retain the site, no house or other building which will be injurious to health or obstructive shall be erected thereon ; or, if purchased by the authority, the obstructive building must be pulled down and the ground kept as an open space, or dedicated as a highway or other public space.

Schemes for Reconstruction.—Section 39 empowers the local authority to prepare such schemes in any of the following cases—(*a*) where an order has been made for demolition, and it appears to the local authority that it would be beneficial to the inhabitants of the neighbouring houses if the site were used as a highway or open space, or appropriated, sold, or let for the erection of dwelling-houses for the working-classes, or exchanged for other neighbouring land more suitable for that purpose ; or (*b*) where the closeness, narrowness, and bad arrangement or bad condition of any buildings, or the want of light, air, ventilation, or proper conveniences, or any other sanitary defect in such buildings is prejudicial to the health of the inhabitants of those or neighbouring buildings, and that their demolition is necessary to remove these evils. When a scheme has been prepared in any of the above cases, notice must be given to the owners and occupiers of the improvement area and a petition forwarded to the Local Government Board, who, after a local inquiry, may make an order sanctioning the scheme with or without modi-

fications. When this order has been made, the authority may purchase by agreement. Where no such agreement can be made, notice of the order must be published in the *London Gazette* and served on the owners; and it is only in cases where a petition is presented and not withdrawn that the order will require confirmation by Parliament. The order may require provision to be made for the accommodation of the working-classes displaced (Section 40).

In respect to compensation, Section 41 provides that the arbitrator shall base his estimate on the same lines as those already set forth in Section 21, Part I.

When an official representation or complaint has been made under Part II., or a closing order has been made, Section 45 requires a rural sanitary authority to forward forthwith a copy of such representation, complaint, or closing order to the County Council, and report from time to time all further proceedings. Such requirement also applies to all vestries and local district boards in the county of London. If the County Council are of opinion that a vestry, district board, or rural sanitary authority have failed to perform their duties in relation to the closing or demolition of any such dwelling-house, or the pulling down of any such obstructive building, they may themselves take the necessary proceedings for this purpose; and in the event of proceedings being successful and not being disallowed on appeal, they are empowered to recover the expenses incurred by them from the local authority. These powers, however, will not be exercisable until reasonable notice—not being less than one month—has been given in writing to the authority. The County Council and their officers, for the purposes of this section, have the same right of entry on premises as any local authority or their officers, and a justice may make an order for enforcing such admission. Section 52 further provides that a representation from the medical officer of health of any county, submitted to the County Council and forwarded to the local authority, not being a borough as defined by the Municipal Corporations Act, 1882, shall, for the purposes of this Act, have the like effect as a representation from the medical officer of health for the district.

Part III

This part of the Act, which applies to labouring class lodging-houses, may be adopted by local authorities, provided that in the case of *urban* authorities the sanction of the Local Government Board is obtained; and in respect to *rural* authorities, the sanction of the County Council, after local inquiry. It enables local

authorities to purchase or rent land for the erection of lodging-houses, and in *rural* districts this expression includes separate houses or cottages, whether containing one or several tenements. *Rural* authorities are also empowered, with the sanction of the County Council, to provide lodging-houses on land so purchased or rented, or appropriated if vested in them, and to convert any buildings into lodging-houses, and to alter, enlarge, repair, and improve the buildings, and to fit up, furnish, and supply them with the requisite furniture, fittings, and conveniences. It further enables *rural* authorities to contract for the purchase or lease of any lodging-houses for the working-classes already or hereafter to be built and provided, and with the consent of the County Council to appropriate the same for the purposes of this part of the Act, and to sell with such consent any land vested in them for these purposes, and to apply the proceeds in or towards the purchase of more suitable lands (Sections 53-60).

The management, regulation, and control of such lodging-houses are vested in the local authority, and for these purposes the authority is empowered to make bye-laws (Sections 61, 62).

In the county of London, the administration of Parts I. and III. are vested in the County Council, and Part II. primarily in the district councils. In the event of doubt or dispute the Secretary of State decides under which part of the Act a given area shall be dealt with. The County Council may, however, prepare schemes under Part II. if they think fit, and may apply to the Secretary of State to order a contribution from the district authority. In like manner, if the district authority resolve to proceed they may apply for a contribution from the County Council (Sections 72-93).

In Scotland, the approving authority substituted for the Local Government Board is the Secretary for Scotland ; and as regards the adoption and execution of Part III. a local authority, being a district committee, is substituted for a rural authority, and the Board of Supervision for the County Council (Sections 94-97).

In Ireland, the Local Government Board, Ireland, becomes the approving authority, and Part III. of the Act may be adopted in any town, not being an urban district, by the Commissioners appointed for the time being for paving, lighting, or cleansing, and carried into execution by them (Sections 98-101).

XIII.—THE LOCAL GOVERNMENT ACT, 1888

Apart from the powers in respect to the prevention of pollution of rivers conferred on them by Section 14,

and the powers referred to above in the Housing of the Working Classes Act, County Councils are vested with few sanitary functions.

Section 17 empowers a County Council to appoint one or more medical officers of health for a county, and Section 19 enacts that copies of all periodical reports which have to be forwarded to the Local Government Board must be transmitted to them by the medical officers of districts, or parts of districts, situated in the county. If it appears to a County Council from any such report that the provisions of the Public Health Act, 1875, have not been properly put in force within the district to which the report relates, or that any matter affecting the health of the district requires to be remedied, Section 19 further authorises the Council to cause a representation to be made to the Local Government Board on the matter. Section 16 empowers them, subject to the approval of the Local Government Board, to make bye-laws in relation to the whole or any specified part of a county, boroughs excepted, for several purposes including the suppression of nuisances not already punishable in a summary manner by any Act in force throughout the county.

XIV.—THE SALE OF HORSEFLESH, etc., REGULATION ACT, 1889

This Act, which extends to Scotland and Ireland, provides that horseflesh shall not be sold for human food elsewhere than in a shop, stall, etc., conspicuously labelled as a place where horseflesh is sold, and it gives the medical officer of health and sanitary inspector powers of entry, inspection, and seizure. The penalty for a breach of the Act is £20. "Horseflesh" includes the flesh of "asses and mules," and means "horseflesh" cooked or uncooked, alone or in combination with any other substance.

XV.—THE INFECTIOUS DISEASES (NOTIFICATION) ACT, 1889

This Act is compulsory in London, but can only be adopted in other parts of the country by a special resolution of the sanitary authority, which must be duly advertised in a local paper, and by handbills, but the Act

cannot come into operation until at least one calendar month has elapsed after publication of the resolution. The diseases scheduled in the Act are :—*Small-pox, cholera, diphtheria, membranous croup, erysipelas, scarlatina* or *scarlet fever,* and the fevers known as *typhus, typhoid, enteric, relapsing, continued,* or *puerperal.* Sanitary authorities, however, are empowered by special resolution duly advertised as above, to order that the Act shall apply to any dangerous infectious disease other than those mentioned. The order may be for a stated time or permanent, but no such order, or any revocation or variation of it, will be of any validity until approved by the Local Government Board.

Section 3 provides that where an inmate of any building used for human habitation within a district to which the Act extends, is suffering from any infectious disease to which the Act applies, then, unless such building is a hospital in which persons suffering from an infectious disease are received, the following provisions shall have effect :—

(*a*) The head of the family to which such inmate (in the Act referred to as the patient) belongs, and in his default the nearest relatives of the patient present in the building or being in attendance on the patient, and in default of such relatives every person in charge of or in attendance on the patient, and in default of any such person the occupier of the building, shall, as soon as he becomes aware that the patient is suffering from an infectious disease to which the Act applies, send notice thereof to the medical officer of health of the district.

(*b*) Every medical practitioner attending on or called in to visit the patient shall forthwith, on becoming aware that the patient is suffering from an infectious disease to which the Act applies, send to the medical officer of health for the district a certificate stating the name of the patient, the situation of the building, and the infectious disease from which, in the opinion of such medical practitioner, the patient is suffering.

Every person required by this section to give a notice or certificate who fails to give the same, will be liable on summary conviction to a fine not exceeding forty shillings. If, however, a person is not required to give notice in the first instance, but only in default of some other person, he will not be liable to any fine if

he satisfies the Court that he had reasonable cause to suppose that the notice had been duly given.

A notice or certificate to be sent to a medical officer of health in pursuance of the above provisions may be sent by being delivered to him, or by being left at his office or residence, or may be sent by post addressed to him at his office or at his residence. Where in any district of a local authority there are two or more medical officers of health of the authority, the certificate must be given to such one of them as has charge of the area in which is the patient referred to in the certificate, or to such other of them as the local authority may from time to time direct.

Section 13 enacts that the provisions of the Act shall apply to every ship, vessel, boat, tent, van, shed, or similar structure used for human habitation, in like manner as nearly as may be as if it were a building, and that a ship, vessel, or boat lying in any river, harbour, or other water not within the district of any local authority within the meaning of the Act shall be deemed, for the purposes of the Act, to be within the district of such local authority as may be fixed by the Local Government Board, and where no local authority has been fixed, then of the local authority of the district which nearest adjoins the place where such ship, vessel, or boat is lying. This section will not, however, apply to any ship, vessel, or boat belonging to any foreign Government, nor will the Act extend to any building, ship, vessel, boat, tent, van, shed, or similar structure belonging to Her Majesty the Queen.

Forms of certificate, prescribed by the Local Government Board are issued gratuitiously by the sanitary authority to every medical practitioner practising in any district in which the Act is in force, and a fee of 2s. 6d. is allowed him for each certificate sent by him in accordance with the Act if the case occurs in his private practice, and of 1s. if the case occurs in his practice as medical officer of any public body or institution.

Although it is seen from the above excerpts that the system of notification laid down by the Act is what is called the dual system, in practically carrying out the provisions of the Act, the householder's obligation to notify is, by the tacit agreement of all parties allowed to lapse, and the only certificate forwarded is that of the

medical attendant. If, however, the householder or person in charge of the patient, either through negligence or with a view to concealment, does not call in a medical attendant, and fails to notify, the part of Section 3 applying to him should be enforced by the sanitary authority; or, if the case is not a glaring one, he should be called upon to show reason why he should not be summoned, and this of itself has often a very salutary effect. At the same time it should be noted that the Act gives no power of entry for the purpose of making inquiries, nor does it give any power for compulsory removal of a patient to a hospital.

As regards combined districts, the Local Government Board has ruled, that the intentions of the Act are fully met if the address or office of the sanitary inspector of any district is made the address or office of the medical officer of health, but in this case the certificate should be addressed to the medical officer of health, *care of* sanitary inspector of such district, and naming both officers. This plan saves delay as regards immediate inquiry, and especially when it becomes necessary to remove a patient to hospital, when recommended or certified fit for removal by the medical attendant. All certificates, however, together with particulars of inquiry and action taken, should be forwarded by the inspector to the medical officer of health without delay, who may then visit or not as circumstances require. All forms of certificate should have the address of the medical officer of health printed on the back.

XVI.—THE INFECTIOUS DISEASES (PREVENTION) ACT, 1890

This Act is supplemental to the Notification Act, and like it, was made compulsory in London and Woolwich

but adoptive in other parts of the country. The two Acts also correspond as regards the method of adoption and the diseases involved, but with this difference that the Prevention Act can be either wholly or partially adopted, and may be revoked if desired. The important sections are the following:—

1. *Milk Supplies.*—Section 4 enacts that if the medical officer has reason to believe that any person in his district is suffering or likely to suffer from infectious disease attributable to milk supplied within his district, from any dairy situate within or without his district, he may, if authorised by a justice having jurisdiction in the place where the dairy is situate, inspect such dairy. He is further empowered, if accompanied by a veterinary surgeon to inspect the animals in such dairy, and if he is of opinion that infectious disease is caused by consumption of the milk, he must report to the authority, and at the same time forward any report furnished to him by the veterinary surgeon. The authority may thereupon give not less than twenty-four hours' notice to the dairyman to appear before them, and show cause why an order should not be made requiring him not to supply any milk from the dairy until such order has been withdrawn. If in their opinion he fails to show cause, the authority may order accordingly, but notice of the facts must forthwith be given by the local authority to the sanitary authority and County Council of the district or county in which the dairy is situate, and also to the Local Government Board. The order, however, must be forthwith withdrawn on the local authority or medical officer of health being satisfied that the milk supply has been changed, or that the cause of infection has been removed. Any one refusing to permit the medical officer of health to inspect any dairy on the production of such order aforesaid, or who, after order has been given to prohibit the supply, disobeys such order, shall be deemed guilty of an offence under the Act, provided that proceedings shall be taken before the justices having jurisdiction in the place where the dairy is situate, and provided also that no dairyman shall be liable for breach of contract if the breach be due to an order under this Act.

It may here be observed in passing that the legal enforcement of this important section necessitates delay in stopping a milk-supply which may in many instances involve serious consequences, but the medical officer of

health, if fully satisfied that there is grave danger, will, as a rule, have no difficulty in inducing the dairyman to stop his supply forthwith, and also to give him a list of his customers, by promising him every assistance for the renewal of his trade when all risk is past if he complies with his advice, and pointing out to him the blame which will attach to him in the event of his refusing compliance. He should at the same time frankly explain to the dairyman the provisions of the section, and he will further find that the dread of publicity will have a much greater effect than the fear of a fine. The Act defines a dairy as including any farm, farmhouse, cow-shed, milk store, milk shop, or other place from which milk is supplied or in which it is kept for the purposes of sale.

2. *Disinfection.*—Section 5 provides that in any district where this section has been adopted Section 120 of the Public Health Act, 1875 (see *ante*, p. 626), shall be repealed, and the following provisions shall be in force :—(1) Where the medical officer of health or any other registered practitioner certifies that the cleansing and disinfection of any house or part thereof, and of any articles therein would tend to prevent infection, the clerk to the local authority shall give written notice to the owner or occupier, that the cleansing and disinfection of such house and articles will be carried out by the local authority, at the cost of such owner and occupier, unless he informs the authority within twenty-four hours from the receipt of the notice, that he will himself cleanse and disinfect to the satisfaction of the medical officer of health within a time fixed in the notice. (2) If he fails to do this within the specified time, the cleansing and disinfection shall be carried out by the officers of the authority under the superintendence of the medical officer of health, and the expenses may be recovered. (3) In the event of the owner or occupier being unable to effectually cleanse and disinfect, the work may be done, with consent, by the local authority. For the purpose of carrying out the provisions of this section, powers of entry between 10 A.M. and 6 P.M. are given by Section 17.

Section 6 provides that the local authority or their medical officer of health may, by written notice, require (under penalty) any infected clothing or other articles to be delivered to their officer for disinfection. The authority must take away, disinfect,

and return such articles free of charge, and, in the event of any unnecessary damage, must compensate the owner.

Section 7 enacts that any person who shall cease to occupy any house or room in which any person has, within six weeks, been suffering from any infectious disease, without having such house or room, and all articles therein liable to retain infection, disinfected to the satisfaction of a registered medical practitioner, as testified by a certificate signed by him ; or without giving the owner notice of the previous existence of such disease ; or who knowingly makes a false answer when questioned by the owner, or by any person negotiating for the hire of the house or room, as to there having, within six weeks previously, been therein any person suffering from any infectious disease, shall be liable to a penalty not exceeding £10. The local authority must give notice of the provisions of this section to the occupier of any house in which they are aware there is a person suffering from an infectious disease.

3. *Prompt Interment.*—Sections 8, 9, and 10 refer to prompt interment (see Mortuaries, page 538).

4. *Public Conveyances.*—Section 11 provides for the disinfection of any public conveyance otherwise than a hearse, used for the conveyance of an infected body. Any one who hires a conveyance to be so used without giving notice to the owner or driver, or any owner or driver who does not immediately provide for the disinfection of such conveyance after it has been so used, is liable to a penalty.

5. *Detention in Hospital.*—Section 12 authorises justices of the peace to order the detention in hospital, at the cost of the local authority, of any person suffering from infectious disease who would not be provided with lodging accommodation in which proper precautions could be taken to prevent the spread of the disease by such person. Any order so made must state a specified time, but with full power of renewal if deemed necessary.

6. *Infectious Rubbish.*—Section 13 enacts that any one who knowingly casts or permits to be cast into any ash-pit, ash-tub, or other receptacle for the deposit of refuse matter, any infectious rubbish without previous disinfection, shall be guilty of an offence under the Act.

7. *Temporary Shelter.*—Under Section 15 the local authority is empowered to provide shelter with attendance for the members of any family in which infectious disease has appeared, who have been compelled to leave their dwellings in order that they may be disinfected by the authority.

XVII.—THE PUBLIC HEALTH ACTS (AMENDMENT) ACT, 1890

This Act is divided into five parts, namely, Part I., General; Part II., Telegraphs; Part III., Sanitary and other Provisions; Part IV., Music and Dancing; and Part V., Stock. Part I. extends to England and Wales, exclusive of London, and also to Ireland. The other parts extend to any district in which they are adopted, and the mode of procedure for adoption is similar to that laid down for the adoption of the two previous Acts.

Section 3 provides that an *urban* authority may adopt all or any parts of the Act, and a *rural* authority Part III. so far as it is applicable to such authority. Section 5 empowers the Local Government Board to declare that any of the provisions contained in any part of this Act which are not in force in any *rural* district shall be in force in that district or any part thereof, and may invest a *rural* authority with any of the powers which an *urban* authority may acquire by adoption of any part of this Act, in like manner, and subject to the same provisions as they are enabled to invest sanitary authorities with urban powers under Section 276 of the Public Health Act, 1875 (see *ante*, p. 635), and in such case the date of the declaration of the Local Government Board under this section shall be substituted for the date of adoption. Section 6 enacts that offences under the Act may be prosecuted, and penalties, etc., and expenses recovered subject to the same provisions as under the Public Health Acts. Section 11 defines "ash-pit" as including any ash-tub or other receptacle for the deposit of ashes, fæcal matter, or refuse.

Part III. applies specially to sanitary matters, and its chief provisions are as follows:—

1. *Sewers and Drains.*—Section 16 and 17 render it unlawful to throw or pass into any sewer or drain communicating therewith (1) any matter or substance which will injure such drain or sewer, or impede the flow of its contents; (2) any chemical refuse; (3) any waste steam or water or other liquid of a higher temperature than 110° Fahr. For the purposes of examining whether the provisions of these two sections are contravened, powers of entry

are given to local authorities and their officers, and any contravention renders the offender liable to a penalty, absolutely as regards (1), and subject to notice of the provisions being given as regards (2) and (3). Section 18 empowers a local authority, where a person is entitled to drain into a public sewer, to make the connection and carry out all necessary works if requested to do so, and provided the cost thereof, which is to be estimated by the surveyor, is paid in advance ; and they are further empowered, by agreement, to make, alter, or enlarge any private drain or sewer which the owner is required or desires to make, alter, or enlarge. Section 19 provides that where two or more houses are connected with a public sewer by a private drain, and a complaint is made under Section 41 of the Public Health Act, 1875 (see p. 611), the local authority may carry out the necessary works on application made to them, and recover the expenses incurred.

2. *Sanitary Conveniences.*—Section 20 enacts that where an *urban* authority provide and maintain for public accommodation any sanitary conveniences, they may (1) make regulations for the management thereof, and bye-laws for decent use ; (2) may let the same for any term not exceeding three years ; and (3) may charge fees for the use of any water-closets. No public sanitary convenience can be erected in or accessible to any street without the consent of the sanitary authority, and on such terms as regards use and removal as they may think fit. Any contravention of this enactment renders an offender liable to a penalty. This section, however, does not apply to railway companies in respect to sanitary conveniences within their own property.

As regards sanitary conveniences used in common by the occupiers of two or more dwelling-houses, Section 21 enacts that (1) any person fouling or injuring such convenience is liable to a penalty, and (2) that if nuisance arises from want of cleanliness of any part of a convenience, or of the approaches thereto, each of the persons having the right of use is liable to a penalty, if it cannot be proved which of them is in default. Section 22 enacts that sufficient and suitable sanitary conveniences must be provided for all workshops and manufactories, with separate accommodation for each sex where persons of both sexes are employed. If the surveyor reports that the provisions of this section are not complied with, the authority may give notice, and failing compliance, a penalty not exceeding £20 is incurred. Where the above section is in force, Section 38 of the 1875 Act is repealed (see *ante*, p. 610).

3. *Bye-laws.*—Section 23 provides (1) that 157 of that Act (see *ante*, p. 630), shall be extended so as to empower every *urban* authority to make bye-laws concerning new buildings with respect to

the following matters :—(*a*) Sufficient water-supply to flush closets ; (*b*) structure of floors, hearths, and stair-cases ; (*c*) height of rooms intended for human habitation ; (*d*) paving of yards and open spaces in connection with houses ; (*e*) laying out of new streets of secondary means of access, for the removal of house refuse and other matters. (2) Any bye-laws under that section respecting drainage, the flushing of water-closets, or the construction of earth-closets, privies, ash-pits, and cesspools may be made so as to affect buildings erected before the passing of the Act. (3) The provisions of the said section, as amended by this Act, so far as they relate to bye-laws with respect to the structure of walls and foundation of new buildings for purposes of health, and with respect to the matter mentioned in Sub-sections (3) and (4) of the said section, and with respect to the structure of floors (see *ante*, p. 630), the height of rooms for human habitation, and to the keeping of water-closets supplied with sufficient water for flushing, shall be extended so as to empower *rural* authorities to make bye-laws in respect to the said matters, and to provide for the observance of such bye-laws, and to enforce the same as if such powers were conferred on *rural* authorities by virtue of an order of the Local Government Board made on the day when this part of this Act is adopted ; and Section 158 of the Public Health Act, 1875, shall also apply to any such authority and shall be in force in every rural district where this part of this Act is adopted. (4) Every local authority may make bye-laws to prevent buildings which have been erected in accordance with bye-laws made under the Public Health Acts from being altered in such a way that if at first so constructed they would have contravened the bye-laws.

Section 26 empowers an *urban* authority to make bye-laws with respect to the carriage through the streets of fœcal or offensive matter or liquid, prescribing (*a*) certain hours for such removal ; (*b*) proper construction and covering for the cart or receptacle for removal of such matter to prevent spilling ; and (*c*) compelling the cleansing of any such matter or liquid dropped or spilled. Where any local authority themselves undertake or contract for the removal of house refuse, they may make bye-laws imposing upon the occupier duties in connection with such removal.

4. *Rooms over Privies, etc.* — Section 24 prohibits, under a penalty, after seven days' notice, the occupation of any portion of a room whether as a living-room, sleeping-room, or workroom which extends immediately over any privy (not being a water-closet or earth-closet), or over any cesspool, midden, or ash-pit.

5. *Polluted Sites.*—Section 25 enacts that no new building may be erected upon ground impregnated with animal or vegetable

matter, or upon which such matter has been deposited unless such matter has been properly removed or has been rendered or become innocuous. Any one wilfully contravening this section is liable to a penalty not exceeding £5, and a daily penalty not exceeding forty shillings.

6. *Cleansing of Common Passages.*—Section 27 provides that if in an *urban* district, any private court or passage, leading to the back of several buildings separately occupied, is not regularly and effectually swept and kept clean, the authority may cause it to be swept and cleaned.

8. *Articles of Food.*—Section 28 enacts that Sections 116 to 119 of the Public Health Act, 1875 (see *ante*, p. 624), shall extend and apply to all articles intended for the food of man, sold or exposed for sale, or deposited in any place for the purpose of sale, or of preparation for sale, within the district of any authority. A justice may condemn such article and order it to be destroyed if satisfied, on complaint being made to him that such article is diseased, unsound, unwholesome, or unfit for the food of man, although the same has not been seized as mentioned in Section 116 of the 1875 Act.

9. *Slaughter-houses.* — Section 29 provides (1) that licences granted after the adoption of this Act shall remain in force only for such period, not being less than a year, as the *urban* authority may specify in the licence ; (2) that every change of occupation of a licensed or registered slaughter-house must, under a penalty, be notified by the occupier to the inspector of nuisances ; and (3) that notice of this enactment shall be endorsed on all licences granted after the adoption of this part of the Act. Section 31 empowers a court of summary jurisdiction to revoke the licence, if the occupier of any slaughter-house, so licensed, is convicted under Sections 116 to 119 of the 1875 Act.

10. *Common Lodging-houses.*—Section 32 imposes a penalty on any keeper of a common lodging-house if he fails to give notice of any case of infectious disease as required by Section 84 of the 1875 (see *ante*, p. 613).

11. *Buildings.*—Section 33 provides that buildings described in deposited plans otherwise than as dwelling-houses may not be used as such under a penalty, unless any such building has in the rear thereof such open space as is required by the bye-laws, and the part of the building intended to be used as a dwelling has undergone such alterations as are necessary in the opinion of the local authority to render it fit for human habitation.

12. *Other Provisions.*—Sections 34 to 46 provide *inter alia* for boards to be set up during progress of buildings ; repair of cellars

under streets; sufficient means of ingress to and egress from places of public resort erected after the adoption of this part of the Act, such as churches, chapels, theatres, concert-rooms, and the like; safety of platforms erected on public occasions; bye-laws for whirligigs and shooting-galleries; construction and maintenance of raised platforms or refuges in streets; provision and maintenance of cabmen's shelters; adoption of private streets; planting of trees in roads; and setting apart the use of public parks and pleasure grounds for special purposes for any number of days not exceeding twelve during the year, or four consecutively.

13. *Protection of Streams.*—Section 47 prohibits, under penalty, the throwing or placing of any cinders, ashes, brick, stone, or rubbish into any stream, river, or watercourse within any district in which this part of the Act has been adopted.

XVIII.—THE PUBLIC HEALTH (LONDON) ACT, 1891,

which came into force on 1st January 1892, does for London what the Public Health Act of 1875 did for the rest of the country. Its provisions, however, are more extensive, and in many respects it is of a more compulsory character. It repealed and consolidated sixteen Acts of Parliament and parts of eighteen more, and embodied the Infectious Diseases Notification and Prevention Acts. As pointed out in the beginning of this chapter, it contains provisions which are of special importance to medical officers of health, and it substitutes the designation "sanitary inspector" for the old offensive title of "inspector of nuisances," which, though still retained in the Public Health Acts applying to the rest of the country, has long since become a misnomer.

SECTION V.—BYE-LAWS AND REGULATIONS

In a circular first issued by the Local Government Board in 1877 for the guidance of local authorities in framing bye-laws, under the Public Health and other Sanitary Acts, they point out that, in accordance with

Section 182 of the 1875 Act, a bye-law to be in harmony with the laws of England must be certain and determinate, and likewise reasonable. It will also be invalid if it be repugnant to the provisions of the Act under which it has been framed. Parliament has distinctly specified a variety of purposes for which bye-laws may be made, and for these purposes alone are they authorised. Sanitary authorities cannot legally assume the power of making bye-laws for the carrying out the general objects of any Act which empowers them to make bye-laws. It follows, therefore, that every bye-law must be strictly limited with reference to the terms of the specific enactment from which its force is derived. Moreover, it should always be remembered that bye-laws, to have the force of law, are designed to supplement, and not to vary or supersede, the express provisions of the statute law, though it is quite open to a sanitary authority to append a summary of the requirements of the statute bearing upon the same matters.

All bye-laws to have effect must be duly advertised, and, so far as sanitary authorities in England and Wales are concerned, they must be submitted to, and receive the approval of, the Local Government Board. Every sanitary authority desirous of making new bye-laws or of amending existing bye-laws will, on application, be supplied by the Board with draft forms. These forms contain the whole of the clauses comprised in the model series, with an ample margin for annotations. As a rule, sanitary authorities are inclined to regard many of these clauses as of too stringent a character, and, though modifications are allowed, the Board expressly state that all bye-laws are open to objection, which, while purporting to lay down rules enforceable by penalties, ignore the necessary details, and substitute vague conditions which render compliance with the bye-laws dependent upon the

approval, by the sanitary authority or their officers, of the mode of proceeding in each case.

Under Section 183 of the Public Health Act, 1875, authorities are empowered in framing any bye-laws to impose reasonable penalties not exceeding £5 for each offence, or £2 : 2s. for each day in the case of a continuing offence, but the Board advise that all such bye-laws should be so framed as to allow the recovery of any sum less than the full amount of the penalty.

In previous chapters, and in Section 4 of this chapter, the more important clauses of the Model Series of Bye-Laws issued by the Local Government Board have already been quoted or summarised, and the following brief summary is intended to be supplemental.

I. *Urban* sanitary authorities are empowered to make bye-laws as under :—

1. *Private Scavenging.*—Where the authority do not undertake or contract for the scavenging of their district, Section 44 of the 1875 Act (p. 611), empowers them to make bye-laws imposing upon the occupiers of premises the duty (*a*) of cleansing the footpaths or pavements adjoining or fronting any street *daily* except Sundays, or on such other days, to be stated in the bye-law, as may be deemed necessary ; (*b*) of removing house refuse *once a week* ; and (*c*) of the cleansing of earth-closets, privies, ash-pits, and cesspools. The Model Bye-Laws suggest the following as the maximum limits which should be allowed for the periodical scavenging of earth-closets, etc.—

Earth-closets with fixed receptacle . . .	Every three months
Earth-closets with movable receptacle	Once a week
Privies, whether the receptacle is fixed or movable .	,,
Ash-pits, whether receiving excreta or not . . .	,,
Cesspools	Every three months

2. *Prevention of Nuisances.*—The same section (44) empowers an authority to impose bye-laws on every occupier, for—

(1.) *Clearing away Snow* from the footways and pavements adjoining premises as soon as possible after it falls.

(2.) *For Scavenging.*—The filth, dust, or ashes from any premises shall not be deposited on any footway, pavement, or carriage way, and must if necessary be removed in a suitable covered receptacle

or cart to prevent spilling. Any such refuse accidentally falling upon a footway or road must be immediately removed, and the place cleaned. If the premises are within 20 yards of any dwelling, school, public building, or place of business, the occupier shall not scavenge any privy or other such receptacle for filth except between the hours of (say) 7 A.M. and 9.30 A.M. during the months of November, December, January, and February, and between (say) 6 A.M. and 8.30 A.M. during the other months of the year.

(3.) *Removal and Deposit of Night-soil or other Filth.*—Any one removing night-soil or other filth through the streets must do so in carts, or rather receptacles which must be covered if deemed necessary to prevent spilling, and any matter so spilled on the streets or roads must be removed and the place cleaned. No load of filth must be deposited within (say) 100 yards of any street, dwelling-house, school, public building, or place of business, nor must it be permitted to remain there for more than (say) 24 hours. Night-soil intended for agricultural purposes must not be deposited on land within (say) 100 yards of any street, or dwelling, etc., and, if not deodorised, must be at once dug or ploughed into the ground. Further powers for framing bye-laws both in respect to scavenging and carriage of night-soil are conferred by the Public Health (Amendment) Act (see *ante*, p. 681).

(4.) *Keeping of Animals.*—Swine shall not be kept within (say) 60 or 100 feet of any dwelling-house, nor in such a situation as to pollute water likely to be used for domestic or dairy purposes, or the manufacturing of drinks. The same prohibition as regards water-pollution apply to the keeping of cattle and the storage of dung.

(5.) *Construction of Premises.*—Every occupier of premises in which swine, cattle, horses, etc., are kept must provide a suitable receptacle for dung, manure, etc. Such receptacle must be entirely above the level of the ground, be made water-tight so as to prevent soakage, and be furnished with a suitable cover. It must be cleansed (say) once a week, and provided with a drain properly constructed and kept in order at all times, so as to convey all liquid filth to a sewer, cesspool, or other suitable receptacle.

3. *New Streets and New Buildings.*—The bye-laws under this heading are authorised by Section 157 of the 1875 Act (see p. 630). Summaries of the Model Bye-Laws will be found embodied in previous chapters with reference to the following :—(1) Width of streets and free air-space around new buildings (p. 382) ; (2) structure of walls, foundations, roofs, and chimneys of new buildings (pp. 381 and 383-385) ; (3) ventilation (p. 385) ; (4) drains (pp. 305-317) ; (5) water-closets (pp. 296-305) ; (6) privies and earth-

closets (p. 328); (7) ashpits, which must be constructed so that the floor shall be at least 3 inches above the ground-level, must also be properly paved and cemented, furnished with a suitable covering, be situated at a prescribed distance from any well, be easy of access, and should not be of a cubic capacity exceeding (say) 6 cubic feet (p. 329); and (8) cesspools, which must be situated at a prescribed distance from any well, be accessible, be constructed of good brick-work laid in cement, with clay-puddling at least 9 inches thick all round and beneath, be properly covered in and well ventilated, and shall not communicate with any public sewer (p. 316). Bye-laws under this heading are also authorised with respect to the depositing of plans of new streets and buildings; the power of the authority to remove, alter, or pull down any work begun or done in contravention of the bye-laws, and with respect to the closing of buildings unfit for human habitation. Further powers as to the framing of bye-laws in several of these respects are now authorised by the adoption of the Public Health (Amendment) Act, Section 23, and some of them may be made to apply to old buildings as well as new (p. 680).

4. *Common Lodging-houses.*—Bye-laws in respect to these are authorised by Section 80 of the 1875 Act, and have been summarised under that section (p. 614).

5. *Houses let in Lodgings.*—Bye-laws are authorised by Section 90 of the 1875 Act (p. 615), for dwellings for the labouring classes, by the Housing of the Working Classes Act, Section 62 (p. 671), and by the Merchant Shipping (Fishing Boats) Act, 1883, for the regulation of seamen's lodging-houses (p. 658).

6. *Tents and Vans.*—Bye-laws with respect to these are authorised by the Housing of the Working Classes Act, 1885 (p. 663).

7. *Hop-pickers' Lodgings.*—Section 314 of the 1875 Act (p. 658).

8. *Fruit-pickers' Lodgings.*—Fruit-Pickers' Act (p. 658).

9. *Slaughter-houses.*—1875 Act (p. 631). Further powers as regards licensing and revoking of licence without bye-laws are authorised by the Public Health (Amendment) Act (p. 682).

10. *Offensive Trades.*—Bye-laws in respect to these are authorised by Section 113 of the 1875 Act, and are summarised under that section (p. 622).

11. *Baths and Bathing.*—Baths and Wash-houses Acts (p. 650).

12. *Markets and Fairs.*—1875 Act, Section 167 (p. 631).

13. *Open Spaces.*—1875 Act, Section 164 (p. 631), and also under the Open Spaces Act, 1887, for the regulation of any open space, churchyard, or cemetery over which the authority has control.

14. *Cemeteries.*—Public Health (Interments Act), 1879, with respect to management and regulation of charges (p. 543).

15. *Mortuaries.*—1875 Act, Section 141, for the regulation of charges and management (p. 538).

16. *Public Conveniences.*—Public Health (Amendment) Act, Section 20 (p. 680), by adoption.

17. *Other Bye-laws.*—Urban authorities are also authorised to frame bye-laws in respect to hackney carriages, horses, etc., let for hire, and pleasure-boats.

The Model Bye-laws framed by the Local Government Board deal definitely with respect to almost all the purposes for which bye-laws are authorised, as enumerated above.

II. *Rural* authorities have the same powers as urban authorities to make bye-laws in respect to the following, under the enactments already quoted:

(1) Private scavenging; (2) common lodging-houses; (3) houses let in lodgings; (4) seamen's lodgings; (5) tents and vans; (6) hop-pickers'; (7) fruit-pickers'; (8) cemeteries; (9) mortuaries.

The Local Government Board, under Section 276 of the 1875 Act (p. 635), may confer upon them any other powers as to the framing of bye-laws which the Public Health Acts confer on urban authorities, while, by adopting certain portions of the Public Health (Amendment) Act, they can make certain bye-laws in respect to old as well as new buildings, closets, and drainage. The framing of bye-laws in respect to common lodging-houses is compulsory, if any exist in a rural district, but for all other purposes it is optional. Indeed, it may be said that the great majority of rural authorities throughout England and Wales have neither applied for urban powers, nor have they any bye-laws which they are authorised to make without such powers.

As regards regulations, every sanitary authority is empowered to make regulations under the Cow-sheds' and Dairies' Order, 1885, for purposes which have already been quoted (p. 661). Section 125 of the 1875 Act also empowers them to make regulations for the removal to,

and detention in, hospital, as long as may be deemed necessary, of persons brought within their district by ship or boat suffering from dangerous infectious disease (see p. 627), and Section 143 of the same Act empowers them to make regulations for the management of post-mortem rooms (p. 539).

Regulations made by an *urban* authority with respect to the duties and conduct of officers or servants, under Section 189 of the 1875 Act, do not require confirmation by the Local Government Board.

SECTION VI.—DUTIES OF MEDICAL OFFICERS OF HEALTH REQUIRED FOR THE EFFICIENT EXECUTION OF THE SANITARY ACTS.

1. *Routine of Duty.*—It will be seen from the last two sections that while the legislature has conferred on sanitary authorities ample powers, and imposed on them important obligations, both in respect to sound sanitation and the control of infectious disease, it has, year by year, extended the duties and responsibilities which devolve on sanitary officials, and more particularly on medical officers of health. These duties will, of course, vary greatly, according to the nature of the appointment.

(1.) *County Medical Officers of Health.*—For these officers no special duties are prescribed, beyond those attaching to the limited sanitary functions of County Councils, and only a few have as yet been appointed. A county health officer will receive and summarise all the annual and special reports of the district health officers, advise the Council when representations based on these reports should be made to the Local Government Board, inspect and report under the Rivers Pollution Act when requested to do so, and inspect and report when the Council takes action under the Housing of the

Working Classes Act. He may, by the voluntary assistance of the district health officers, and if authorised by the Council, organise a central bureau for the notification of infectious diseases, provided the Notification Act has been generally adopted throughout the county, and if appealed to by district authorities or their health officers his advice would no doubt be available and valuable in other directions; but he does not appear to have any powers of inspection or interference beyond those already stated without the concurrence of the district authorities, nor has he any right to dictate to district officers or prescribe forms of report for their use.

In Scotland, the County medical officers, in addition to general supervision, discharge the duties of district medical officers of health, except in respect to Royal or Police Boroughs, which have their own officers.

(2.) *Medical Officers of Health of large Urban or Metropolitan Districts.*—The health officer of such a district must be provided with an office, at which he should regularly attend at a stated hour every morning, in order that he may be interviewed by ratepayers or any one preferring a complaint, and that he may meet the sanitary inspectors, read their reports, examine their diaries and other books, and give them instructions. He himself must keep a diary, and, with or without clerical assistance, he should also keep a complaint book, inspection books, notification of diseases book, etc. Often there is a large amount of correspondence, and as regards this all letters received should be stamped with date of receipt and filed, and all letters sent out should be copied in a book and indexed. He has, of course, to make periodical and special inspections of his district, make representations under the Housing of the Working Classes Act, inquire into outbreaks of infectious disease, and generally to discharge the duties laid down in the instructions

issued by the Local Government Board. Under the Factory Acts he has to inspect bakehouses and factories, has to certify, unless some one else is appointed for the purpose, with respect to the sanitary condition of tenement houses under the Inland and Customs Revenue Act, and will often have to inquire into trade nuisances and inspect slaughter-houses. He may frequently be called upon to certify with respect to the removal of infectious patients to hospital, and will have to advise the sanitary authority or clerk in all cases in which proceedings must be taken. In controlling the spread of infectious disease, all cases of children attending school, which are notified, should be reported to the school authorities.

(3.) *Medical Officers of Health for Combined Districts.*—Fixed daily attendance at an office cannot be expected of an officer of a large combined district, and interviews can only take place by appointment. He should keep a diary and separate inspection books for the several districts under his charge, and such other books as he deems necessary; but these need not be numerous, because he can always refer to the books kept by the sanitary inspectors. His correspondence, which is often large, should be kept up to date, and important letters filed or copied. All complaints which he receives, unless he himself deems it necessary to inspect, should be immediately forwarded to the sanitary inspectors of the districts concerned, for investigation. All returns from the several districts must be filed separately. In carrying out the Infectious Diseases (Notification) Act, certificates addressed to him should be addressed to the care of the sanitary inspectors of the several districts to save time, and after inquiry, be forwarded to him (see p. 675). He must make periodical and special inspections of the whole of the districts under his charge, have frequent interviews with the inspectors so as to supervise and make himself

thoroughly cognisant with the records of their work; and though he is not bound to attend all the meetings of the several sanitary authorities, he should attend frequently and regularly. In other respects he is bound to discharge the duties imposed upon him in the instructions issued by the Local Government Board in respect to each separate district, and submit his reports separately for each district. As regards annual reports, he should endeavour to get them printed in one pamphlet, with a preliminary summary applying to the whole of his district.

(4.) *Port Medical Officers of Health.*—The special duties which devolve on port-officers are the inspection of incoming vessels in which there is reason to believe there is sickness on board. Under the Quarantine Act, all cases of dangerous infectious disease occurring on board a vessel entering any port, and not arriving coast-wise, must be reported to the Customs officers, who forthwith report to the health officer, and detain the ship until she is released on his certificate. It therefore becomes the duty of the port-health officer to visit all suspected vessels personally, or send his inspectors to do so; and if he has reason to believe that there are cases of infectious disease on board, he must himself make personal inquiry and give all necessary instructions for the removal of patients to hospital, and for disinfection. (See also Cholera Order, p. 638.) He is also responsible for abatement of nuisances on board, and the provision of proper water-supply, but these duties may be discharged by his staff.

(5.) *Medical Officers of Health who are not debarred from Private Practice.*—Although the duties prescribed for these officers are the same as those laid down in the instructions issued by the Local Government Board for health officers generally, it may be said that efficient discharge of duty must often be rendered somewhat difficult.

In many districts they are expected to do but little, and that little only when called upon by the sanitary inspector. Such officers must be especially careful to observe the ethics of the profession, and act up to the golden rule, "do to others as you would be done by." Indeed, all health-officers, whether private practitioners or not, should guard against visiting any cases of infectious disease without the consent of the medical attendant, nor, unless under very exceptional circumstances, should any action be taken for the removal of a patient to hospital without his concurrence. It is no part of the routine duty of any medical officer of health, unless he is a port-officer, to visit cases of infectious disease, and the diagnosis of the attendant should never be questioned unless there are the strongest and most obvious reasons for doing so, which should always be frankly stated. A medical officer of health should endeavour to be on friendly terms with all his medical brethren, and never hesitate to court their assistance or advice when he feels he may require them in the discharge of his duties. It need hardly be said that all such favours should be readily and ungrudgingly reciprocated on his part.

2. *Legal Proceedings.* — Unless under exceptional circumstances, the medical officer of health should never conduct a case before the justices,—that is the duty of the clerk to the sanitary authority, or in respect to common nuisances, it is often discharged by the sanitary inspector. Although he will often have to recommend that proceedings be taken, his duty, so far as the prosecution is concerned, should be confined to furnishing a certificate or giving evidence when required. With well-trained inspectors, it is seldom that he will be required to give evidence except as regards cases of overcrowding, infected houses, or exposure of infected persons, clothing, etc., unsound meat, nuisances which are likely to be contested, and offensive trades.

3. *Reports.*—All reports from the medical officer of health to the sanitary authority should be concise and to the point. The stated reports, weekly, quarterly, or otherwise, will deal chiefly with the vital statistics of the district, and enumerate such proceedings as have been undertaken, according to the provisions of the Sanitary Acts, together with any suggestions which he may deem it to be his duty to lay before the sanitary authority from time to time. He should avoid entering into lengthy disquisitions, because he will have the opportunity, at meetings of the sanitary authority, of answering any questions, and justifying his recommendations, should he be called upon to do so. As far as possible he should base his stated reports on a uniform plan, and he may be quite sure that the briefer they are in their completeness, the more they will be appreciated. If they appear in the public newspapers of the district, as will generally be the case, he should endeavour, without being diffuse, to make them readable and instructive, and whenever he considers it necessary to address the public through this channel, with respect to any sanitary dangers to which they may be specially exposed, it is always advisable that his remarks should, in the first instance, be submitted to the sanitary authority. Although he will find the press to be of great assistance in educating the public in sanitary matters, it need hardly be said that he should avoid entering into controversy, and that he should be very careful not to drag the names of private individuals before the public when his reports are printed.

In large urban districts the medical officer of health may deem it necessary to submit weekly reports. As a model of the plan on which such reports may be arranged, the following different headings, under which Dr. Tatham of Manchester issues his weekly health return, may be quoted:—

(1.) Meteorology, sickness, and condition of the public health.

(2.) Notification and local distribution of cases of infectious sickness.

(3.) Hospital isolation of patients suffering from infectious diseases.

(4.) Comparative statistics of births and deaths in recent weekly returns.

(5.) Local distribution of deaths in registration sub-districts. Pauperism—weekly number of persons relieved by the guardians.

(6.) Register of sanitary work done during the week.

(7) Notifications to school authorities of cases of dangerous infectious disease.

Special reports on special subjects, copies of which must be forwarded to the Local Government Board, should always be submitted separately, and not as part of brief periodical reports. As regards quarterly or annual reports spot maps coloured to show the density of population are of great use in illustrating the incidence of disease in large urban districts, and instead of bulky tables, the graphic method of representing statistics is to be commended. It may be mentioned in passing that in Manchester Dr. Tatham sends a spot map, or disease chart, to all the free public libraries and public reading-rooms every week.

So far as the smaller urban and rural districts are concerned, annual reports should be based on the Memoranda on such reports issued by the Local Government Board. In these Memoranda reference is made to different sections of the instructions already quoted (see p. 597), while as regards tables, the tables A and B referred to will be given in the Appendix.

After pointing out that all annual reports should be forwarded to the Local Government Board within six weeks after the close of the year, or if not forwarded within that period, that the Board should be informed as to the reason of the delay, the Memoranda proceed as follows :—

"The report should be chiefly concerned with the conditions affecting health in the district and with the means for improving those conditions. It should consider these subjects with reference to the past and future as well as to the particular year, and the account of the sanitary state of the district generally should, while marking the point that has been reached in the sanitary state and administration of the district, indicate directions for further consideration and action. The sanitary history of the year under review should include a record alike of the proceedings of the medical officer of health himself and of the proceedings taken under his direction or advice. And the tabular statements of sickness and mortality in the district during the year, to be made on the forms supplied for the purpose, should be the subject of comment in the text of the report, in so far as deductions from them may assist the sanitary authority to an appreciation of the lines of action needful in the future.

"The medical officer of health, in reporting his proceedings and advice, will find it advantageous to follow, in the main, the order in which the subject matters of his duty appear in the several paragraphs of Article 18, and herein special care should be taken in reporting on the influences affecting or threatening to affect injuriously the public health within the district, and causes, origin, and distribution of disease within the district, may usefully be the subjects of annual record: and an account be given both of the actual circumstances of the time, and also of any improvement or deterioration that has occurred during the past year in conditions conducive to health or to disease. For example, a vigilant health officer has in his annual report opportunity for stating and restating facts as to water supplies and house construction, conditions of storage and of removal of excremental and other refuse customary in the district; together with facts as to the adequacy or inadequacy of isolation and disinfection in the district, and the like. And such a health officer, reporting on the diseases and their causes within the district, will generally have some instructive details to give, either of conditions newly productive of disease, or of matters that have been remedied with advantage to the public health. In reporting upon Section 3, not only should the fact of having made systematic inspections, but the outcome from those inspections should be duly put on record. They are inspections independent of such inquiries as, under other articles of the Order, the medical officer of health has to make into particular outbreaks of disease, or into unwholesome conditions to which his attention may have been specially called by complaints or otherwise; and will include the house-to-house inspections which may be necessary in particular localities.

"Of these inspections, systematic and occasional, and of the judgment he has formed thereon as to the sanitary state of his district, and of the advice he has in consequence given to the sanitary authority and the action taken by the authority thereon, the annual report should contain a full account.

"In making such systematic inspection, as in much of his other action, the medical officer of health will usually have required the assistance of the inspector of nuisances; and it will be for the medical officer to include in his report an account of the action which, at his instance, the inspector may have taken for the removal of nuisances injurious to health.

"As regards the tabular statements of sickness and mortality only one observation appears to be needful—the district under the superintendence of a medical officer of health will often contain several parts evidently differing in their circumstances, or having very different rates of mortality, either of mortality from all causes, or of mortality from some particular disease or class of diseases. The observation of these differences can scarcely fail to lead to valuable information, and it is in view of such differences that the tabular statements are required in Section 14 to be classified according to *localities*, and that provision for such a classification is made in the forms supplied for returns of deaths. In the absence of any ascertained differences of the above sort, it will still be desirable to classify the deaths of the district according to the part of the district in which they occur; and for this purpose any areas of known population (such as parishes, groups of parishes, townships, or wards) may be taken as representing '*localities*' for the purposes of the Order. Classification on this basis will be likely to lead to the discovery of real differences when the returns for several years can be compared together.—The same considerations apply to the records of sickness (Table B). These records should be tabulated for every sanitary district; and it will be well before proceeding to fill the columns and the blank spaces, to note carefully the headings and the footnotes. These records will have particular interest for districts which have a system of 'notification' and which have provided themselves with public means for isolating cases of infectious sickness.

"What has been said above with regard to the information which an annual report should contain must be understood, not as suggesting that the report should be limited to these subjects, or that more detailed or differently arranged tabular statements may not be added, but as indicating the sort of information required by the Board's Order. Many medical officers of health will doubtless, with great advantage to the administration of their district, furnish

much more detailed information respecting particular questions to which they have been led by the circumstances of the foregoing year to devote attention, or in the investigation of which they may have arrived at valuable conclusions. Any information of this kind will be appreciated by the Local Government Board."

4. *Official Conduct.*—The medical officer of health should always endeavour to encourage an *esprit de corps* in his staff of inspectors not doing their work, although he is legally empowered to act as an inspector, but by proper supervision and inspection assuring himself that they discharge their duties efficiently and with tact. He should listen courteously to any remarks or suggestions which they may make, and if they are trained officers, give them credit for knowing their duties as well as he does his own. If, unfortunately, he should deem it necessary to report any serious delinquency or neglect of duty on their part, he should always frankly commend those who perform their duties satisfactorily. In many small districts this subordination of the sanitary inspector to the medical officer of health is not observed, indeed the relationship is often reversed, but for such reversed relationship the medical officer of health has only himself to blame.

As regards the portion of the community committed to his charge, he should endeavour, conscientiously and to the best of his ability, to fulfil his obligations towards them, and if in practice he should in no wise shirk his public duty even at the risk of losing his best patient.

His relations to the sanitary authority or sanitary committee, as the case may be, should be guided by common sense and a sense of duty. He should always remember that he is their servant and sanitary adviser, not their dictator; and at their meetings he should carefully avoid taking part in discussions on his reports, unless called upon to do so, or in reply to objections.

He should attend all meetings at which his presence is requested or expected; and when he does attend, he should support his views, when called upon, with clearness, firmness, courtesy, and tact. His proposals may be rejected, but if they do not lie within the scope of the statutory enactments requiring their enforcement, he should never resent opposition, but again bring them forward on future occasions. But with regard to breaches of sanitary law, which in spite of his representations may be persistently ignored, he should unhesitatingly point out the obligations which devolve upon the authority, and, failing action, he can always appeal to the Local Government Board by forwarding a copy of any special report which he may deem it necessary to submit to the authority in the first instance. After he has submitted any recommendations, the responsibilities rest on the sanitary authority, not on him. Under all circumstances, however, he should strive to exercise a wise forbearance when he can conscientiously do so, and on all occasions maintain a courteous, dignified, and friendly demeanour towards the sanitary authority, feeling assured that tact and good temper, like good words, "are worth much, and cost but little."

Section VII.—Duties of Sanitary Inspectors

All sanitary inspectors, part of whose salaries are paid by the County Council, are appointed and hold their appointments under the same conditions, as previously pointed out, in respect to medical officers of health appointed under the order of the Local Government Board. Although they may be suspended by a resolution of the sanitary authority, they cannot be dismissed from office without the sanction of the Board. In almost all large towns or metropolitan districts, how-

ever, this protection on the part of the Board is not available, and sanitary inspectors are subject to dismissal without their sanction. In all these cases, the duties will be prescribed by the sanitary authority or their medical officer of health, but every one who desires an appointment as a sanitary inspector will stand a much better chance if he has passed the examination for the certificate granted by the Sanitary Institute.

It will be seen from the subjoined regulations that the objectionable title of "inspector of nuisances" is still the legal title for that officer so far as districts outside the metropolis are concerned, but the Public Health (London) Act, 1891, to which reference has been previously made, enacts that in future "inspectors of nuisances" are to be designated by the more appropriate title of "sanitary inspectors."

The following are the duties prescribed under the order of the Local Government Board issued in March 1891 :—

"(1.) He shall perform, either under the special directions of the sanitary authority, or (so far as authorised by the sanitary authority) under the directions of the medical officer of health, or in cases where no such directions are required, without such directions, all the duties specially imposed upon an inspector of nuisances by the Public Health Act, 1875, or by any other statute or statutes, or by the orders of the Local Government Board, so far as the same apply to his office.

"(2.) He shall attend all meetings of the sanitary authority when so required.

"(3.) He shall by inspection of the district, both systematically at certain periods, and at intervals as occasion may require, keep himself informed in respect of the nuisances existing therein that require abatement.

"(4.) On receiving notice of the existence of any nuisance within the district, or of the breach of any bye-laws or regulations made by the sanitary authority for the suppression of nuisances, he shall, as early as practicable, visit the spot, and inquire into such alleged nuisance or breach of bye-laws or regulations.

"(5.) He shall report to the sanitary authority any noxious or offensive businesses, trades, or manufactories established within the

district, and the breach or non-observance of any bye-laws or regulations made in respect of the same.

"(6.) He shall report to the sanitary authority any damage done to any works of water-supply, or other works belonging to them, and also any case of wilful or negligent waste of water supplied by them, or any fouling by gas, filth, or otherwise, of water used for domestic purposes.

"(7.) He shall from time to time, and forthwith upon complaint, visit and inspect the shops and places kept or used for the preparation or sale of butchers' meat, poultry, fish, fruit, vegetables, corn, bread, flour, milk, or any other article to which the provisions of the Public Health Act, 1875, in this behalf apply, and examine any animal, carcase, meat, poultry, game, flesh, fish, fruit, vegetables, corn, bread, flour, milk, or other article as aforesaid which may be therein; and in case any such article appear to him to be intended for the food of man, and to be unfit for such food, he shall cause the same to be seized, and take such other proceedings as may be necessary in order to have the same dealt with by a justice: provided, that in any case of doubt arising under this clause, he shall report the matter to the medical officer of health, with the view of obtaining his advice thereon.

"(8.) He shall, when and as directed by the sanitary authority, procure and submit samples of food, drink, or drugs suspected to be adulterated, to be analysed by the analyst appointed under 'The Sale of Food and Drugs Act, 1875,' and upon receiving a certificate stating that the articles of food, drink, or drugs are adulterated, cause a complaint to be made, and take the other proceedings prescribed by that Act.

"(9.) He shall give immediate notice to the medical officer of health of the occurrence within the district of any contagious, infectious, or epidemic disease; and whenever it appears to him that the intervention of such officer is necessary in consequence of the existence of any nuisance injurious to health, or of any overcrowding in a house, he shall forthwith inform the medical officer of health thereof.

"(10.) He shall, subject to the directions of the sanitary authority, attend to the instructions of the medical officer of health with respect to any measures which can be lawfully taken by an inspector of nuisances under the Public Health Act, 1875, or under any other statute or statutes, for preventing the spread of any contagious, infectious, or epidemic disease of a dangerous character.

"(11.) He shall enter from day to day, in a book to be provided by the sanitary authority, particulars of his inspections and of the action taken by him in the execution of his duties. He shall also

keep a book or books, to be provided by the sanitary authority, so arranged as to form, as far as possible, a continuous record of the sanitary condition of each of the premises in respect of which any action has been taken under the Public Health Act, 1875, or under any other statute or statutes, and shall keep any other systematic records that the sanitary authority may require.

"(12.) He shall at all reasonable times, when applied to by the medical officer of health, produce to him his books, or any of them, and render to him such information as he may be able to furnish with respect to any matter to which the duties of inspector of nuisances relate.

"(13.) He shall, if directed by the sanitary authority to do so, superintend and see to the due execution of all works which may be undertaken under their direction for the suppression or removal of nuisances within the district.

"(14.) He shall, if directed by the sanitary authority to do so, act as officer of the said authority as local authority under the Contagious Diseases (Animals) Act, 1886, and any Orders or Regulations made thereunder.

"(15.) In matters not specifically provided for in this Order, he shall observe and execute all the lawful orders and directions of the sanitary authority, and the Orders of the Local Government Board which may be hereafter issued, applicable to his office."

As regards port sanitary inspectors, the main duties are thus set forth in the order of the Local Government Board issued in 1883—

"He shall, by inspection of the shipping in the district, keep himself informed in respect of the nuisances existing therein that require abatement under the Public Health Act.

"On receiving notice of the existence of any nuisance on board of any ship or other vessel within the district, or of the breach of any bye-laws or regulations made by the port sanitary authority for the suppression of nuisances, he shall, as early as practicable, visit the vessel, and inquire into such alleged nuisance or breach of bye-laws or regulations.

"He shall give immediate notice to the medical officer of health of the occurrence within his district of any infectious or epidemic disease of a dangerous character, or of the arrival within the district of any ship or other vessel having such disease on board; and whenever it appears to him that the intervention of such officer is necessary in consequence of the existence of any nuisance injuri-

ous to health or of any overcrowding in a vessel, he shall forthwith inform the medical officer thereof."

It will be seen from these regulations that though the sanitary inspector is not expected, unless so far as authorised by the sanitary authority, to act under the special directions of the medical officer of health, it is very desirable that both officers should act in concert, and keep in touch with each other, even in districts where the health officer is a busy medical practitioner. In the smaller urban districts an office for the inspector is usually provided, where he should attend every morning at a fixed hour to receive complaints and write up his books of record. In rural districts an office is seldom provided; but for interviews the inspector should fix a stated hour at which he may be seen at the workhouse before or after each meeting of the guardians.

The books which he will have to keep will vary according to the character of the district; but they should include—(1) a *Pocket Note-Book* arranged so as to afford spaces for the situation of premises, name of owner and occupier, description of premises, number of sleeping-rooms, number in family, nuisances, sanitary defects, water-supply, etc.; (2) a *Complaint Book*, in which all complaints are recorded; (3) a *Diary*, which should be posted up daily; (4) a *Nuisance Record Book*, in which all nuisances and sanitary defects copied from his note-book are recorded and similarly arranged, with date of notice and abatement of nuisance, whether verbal, by letter, or by legal notice; (5) a *Sanitary Survey Book*, in which to record particulars of complete surveys of various parts of his district; (6) a *Copying Letter Book*, in which all important letters should be copied; (7) a *Register* for all cases of infectious disease notified, or which come under his notice; and (8) a *Register* and *Inspection Book* for cow-sheds and dairies. In urban districts he is often ex-

pected to keep a book recording his visits to common lodging-houses, and the number of lodgers between stated intervals, and also a book recording his inspection of slaughter-houses. In districts through which canals pass he will also have to keep a book for the records of his inspections of canal boats, if he is appointed inspector under the Canal Boats Act. All these books, or such of them as are required, should be procured for him by the clerk of the sanitary authority, together with the books of forms of the various notices required by the Public Health Act and other Acts.

At meetings of the sanitary authority or sanitary committee, as the case may be, he should always submit his record of nuisance book, which should be gone through and signed by the chairman, and such other books as the authority may desire to see, and when submitting them he may or may not present a brief report stating the number of notices issued since last meeting, the number of nuisances or other defects removed, and other matters. Although no annual report is required by the Local Government Board regulations, he should always prepare an annual summary, which should be included in the health officer's report; and as regards details, these should be drawn up or tabulated on a uniform plan, which will vary according to the character of the district.

As it is upon him far more than on the medical officer of health that a sanitary authority has to rely for the efficient execution of the sanitary Acts in their district, he should always endeavour to carry out his duties systematically; and this can only be effected by regular periodical inspection. If in a rural district he is specially called upon to visit a particular village, much time can be saved in periodical inspection by devoting the day to inspecting the whole or part of that village. It is only by careful inspection that nuisances and other sanitary

defects can be discovered and removed, and the more thoroughly this is carried out in the first instance the easier will his duties become. In urban districts the general health of the community is largely protected by public water-supplies, efficient systems of drainage, proper closet-accommodation, systematic scavenging, and the enforcement of bye-laws; but in rural districts, and in scattered villages, all these safeguards are either altogether lacking, or protective only to a very limited extent. Hence, apart from the nuisances strictly applicable to the dwellings themselves, such as dampness, dilapidations, uncleanliness, or overcrowding, most of the nuisances met with are connected with pig-keeping, defective drains, polluted wells, and above all, closet-accommodation.

The sanitary defects in and around dwellings have already been described in Chapter XIII., p. 390; the mode of inspection, p. 395; the sources of well-pollution, p. 233; the methods best suited for the removal of nuisances connected with privies, cesspools, ash-pit middens, etc., p. 331; and the treatment of village slops, p. 357; while the special precautions which should be taken to prevent the spread of infectious disease and rules for disinfection have been given in Chapter XVI., p. 530. As regards the important duties of food inspection, the diseases which render the flesh of animals unfit for the food of man have been described in Chapter II., p. 36; the examination of butcher-meat, p. 53; and the examination of fish, vegetables, and other articles of food, p. 58.

For the inspector's duties in respect to food adulteration, see p. 641; cow-sheds and dairies, p. 658; noxious or offensive trades, p. 621; and canal boats, p. 645. His duties in respect to various other matters, the issuing of notices, and applications for summonses have been fully detailed in the summary of the Public Health

Act and other sanitary Acts in Section IV. of the present chapter.

In carrying out these numerous and important duties it is necessary that the inspector should be well acquainted with the various enactments under which his interference is made obligatory, and by which he is empowered to take proceedings, when so authorised by the sanitary authority, but it is by no means desirable that he should be always threatening or invoking the aid of the law. Indeed, an inspector who discharges his duties with tact and discretion will often succeed in procuring the abatement of nuisances and the removal of other sanitary defects by personal interview and by verbal or written notice, far more readily than by issuing the bare legal form of notice without interview or comment. And this applies specially to inspectors in rural and small urban districts; but as already stated, all notices, however given, should be recorded in the nuisance-book with the dates of notice and abatement. All complaints, whether anonymous or not, should receive personal investigation, and as far as possible they should be treated as privileged, so that the name of the informant, if given, should not be divulged. Such betrayal of confidence is always sure to lead to unpleasantness, which would otherwise be avoided. At the same time he should be careful that he is not made the tool of ill-will or spite, and for that reason alone he should inquire personally into the subject of any complaint made to him. While he is bound to exercise a certain amount of toleration, and give reasonable time for the execution of any structural alterations which are called for, he should have no hesitation in dealing promptly with persons who tacitly ignore, or refuse to comply with, notice; and in these cases he should make application for authority to summon after legal notice has been given. In the discharge of his responsible duties

he may expect occasional abuse, but he should always be in the position to be able to take abuse as a compliment, and should it become intolerant or obstructive he can appeal to the authority for legal protection. A judicious officer, however, who is courteous as well as firm, and who discharges his duties without fear or favour, will rarely meet with either abuse or obstruction.

APPENDIX A

I.—SYMBOLS AND ATOMIC WEIGHTS OF THE COMMONER ELEMENTS

Name.	Symbol.	Combining Weight.
Aluminium	Al	27·5
Antimony (Stibium)	Sb	122
Arsenic	As	75
Barium	Ba	137
Bismuth	Bi	210
Bromine	Br	80
Calcium	Ca	40
Carbon	C	12
Chlorine	Cl	35·5
Chromium	Cr	52·5
Copper (Cuprum)	Cu	63·4
Gold (Aurum)	Au	196
Hydrogen	H	1
Iodine	I	127
Iron (Ferrum)	Fe	56
Lead (Plumbum)	Pb	207
Magnesium	Mg	24
Manganese	Mn	55
Mercury (Hydrargyrum)	Hg	200
Nitrogen	N	14
Oxygen	O	16
Phosphorus	P	31
Platinum	Pt	197·1
Potassium (Kalium)	K	39·1
Silicon	Si	28
Silver (Argentum)	Ag	108
Sodium (Natrium)	Na	23
Sulphur	S	32
Tin (Stannum)	Sn	118
Zinc	Zn	65

II.—ENGLISH WEIGHTS AND MEASURES.

a. *Long Measure.*

Inches.						
12 =	1 Foot.					
36 =	3 =	1 Yard.				
72 =	6 =	2 =	1 Fathom.			
198 =	16·5 =	5·5 =	2·75 =	1 Perch.		
7920 =	660 =	220 =	110 =	40 =	1 Furlong.	
63360 =	5280 =	1760 =	880 =	320 =	8 =	1 Mile.

b. *Land Measure.*

Inches.			
7·92 =	1 Link.		
792 =	100 =	1 Chain.	
63360 =	8000 =	80 =	1 Mile.

c. *Nautical Measure.*

Knots.

1 = 6075·6 Feet (or 6080 Feet, Admiralty).

3 = 1 League.

60 = 1 Degree = 69·04 English Miles.

A Cable's length = 607·56 feet = $\frac{1}{10}$th of a Sea Mile.

d. *Square Measure.*

Inches.					
144 =	1 Foot.				
1296 =	9 =	1 Yard.			
39204 =	272·25 =	30·25 =	1 Perch.		
1568160 =	10890 =	1210 =	40 =	1 Rood.	
6272640 =	43560 =	4840 =	160 =	4 =	1 Acre.

640 Acres = 1 Square Mile.

e. *Land Measure (Square).*

Links.			
625 =	1 Perch.		
10000 =	1 Chain.		
25000 =	2·5 =	1 Rood.	
100000 =	10 =	4 =	1 Acre.

f. *Capacity.*

		Cubic Inches
1 Pint	=	34·66
1 Quart	=	69·318
1 Gallon	=	277·274

1 Gallon = 10 lbs. water at 62° Fahr.

1 Cubic Foot = 6·232 gallons.

224 Gallons = 1 ton.

g. Weight.

1 oz. = 437·5 grains.
1 lb. = 16 oz. = 7000 grains.

III.—COMPARISON OF METRICAL WITH ENGLISH MEASURES.

a. Weight.

		Grains.
1 Milligramme	=	0·015
1 Centigramme	=	0·154
1 Decigramme	=	1·543
1 Gramme	=	15·432
1 Kilogramme		= 15432·348 = 2·2 lbs. (Avoir.) = 35·3 oz.

b. Capacity.

		Cubic Inches.
1 Cubic Centimetre	=	0·061
1 Litre	=	61·027

1 Cub. Inch = 16·386 Cub. Cent.
1 Fluid Oz. = 28·35 ,, ,,
1 Gallon = 4·543 Litres.
1 Cubic Foot = 28·2 ,,

c. Length.

1 Metre	=	39·37 Inches.
1 Decimetre	=	3·94 ,,
1 Centimetre	=	0·39 ,,
1 Millimetre	=	0·039 ,,
1 Kilometre	=	1094 Yards.

d. Area.

1 Square Metre	= 10·76 sq. ft.
1 ,, Centimetre	= 0·154 sq. in.
1 ,, Millimetre	= 0·0015 ,,
1 ,, Kilometre	= 247 acres.
1 Hectare	= 2·47 ,,

IV.—TABLE FOR CONVERSION OF ANALYTICAL RESULTS.

To convert parts per 1,000,000 (= mgr. per litre) into grs. per gal., multiply by 0·07.

To convert parts per 100,000 into parts per 1,000,000, multiply by 10·0.

To convert grains per gallon into parts per 1,000,000, multiply by 14·3.

V.—THERMOMETRY.

$$\frac{\overset{(100°)}{\text{Centigrade}}}{5} = \frac{\overset{(80°)}{\text{Réaumur}}}{4} = \frac{\overset{(212°)}{\text{Fahrenheit} - 32}}{9}$$

	Centigrade.	Réaumur.	Fahrenheit.
Water freezes at	0·0	0·0	32·0
Mercury ,, ...	−40·0	−32·0	−40·0
Water, maximum density at .	4·0	3·2	39·2
Water boils at	100·0	80·0	212·0

VI.—BAROMETER SCALES.

Standard pressure	= 760 millimetres	= 29·922 cubic inches.
30 inches	= 762 ,,	
29·5 ,,	= 749 ,,	
29 ,,	= 737 ,,	

VII.—HYGROMETRY AND RAINFALL.

Average rainfall in England is about 30 inches. 1 inch rain per square yard amounts to 4·673 gallons, and 1 inch falling on a square acre = 101 tons = 22624 gallons. (For further particulars, see pp. 192 and 209.)

Examination Question, Cambridge, 1883.

Describe a rain-gauge and the precautions necessary in placing and observing it. What is the average rainfall in England proper? If $\frac{1}{8}$ of an inch of rain falls in 10 minutes, how much water would this give per square mile in 24 hours at the same rate? State the result in gallons and tons.

For first part of question, see p. 195.

Second part:—$\frac{1}{8} \times 6 = \frac{3}{4}$ inch per hour.

$\frac{3}{4} \times 24 = 18$ inches in 24 hours.

$1\frac{1}{2}$ feet $\times 43560 = 65340$ cubic feet per acre.

$65340 \times 640 = 41817600$ cubic feet per square mile.

$41817600 \times 6{\cdot}23 = 260523648$ gallons per square mile.

$$\frac{260523648}{224} = 1163052 \text{ tons per square mile.}$$

If the data above given are used, the calculation is much simpler.

Thus:— $18 \times 101 = 1818$ tons per acre.

$1818 \times 640 = 1163520$ tons per square mile (nearly).

Examination Question, Cambridge, 1888.

What is meant by the dew-point? If the dry bulb temperature is 65° F., the wet bulb 61° F., and Glaisher's factors 1·87 for 61° and 1·82 for 65°, what is the dew-point? Calculate the relative humidity of the air, using the following table of the tension of aqueous vapour in inches of mercury:—

Temperature.	Tension.	Temperature.	Tension.
57·0	·465	61·0	·537
57·5	·473	62·0	·556
58·0	·482	63·0	·576
59·0	·500	64·0	·596
60·0	·518	65·0	·617

For first part of question, see p. 193.

Second part :—$65° - 61° = 4°$.

Multiply by Glaisher's factor (see p. 194).

$1·82 \times 4 = 7·28 =$ the excess of the temperature of the air above that of the dew-point. Therefore the dew-point is

$$65 - 7·28 = \underline{\underline{57·72}}.$$

Third part :—Next we see in the table that the aqueous tension for 57·5 is ·473, and for 58 it is ·482, so that the aqueous tension for the temperature of the dew-point, 57·72, will be as nearly as possible ·478.

The relative humidity is the ratio of the elastic force of vapour at the temperature of the dew-point to the elastic force of vapour at the temperature of the air (see p. 194). Now the elastic force of vapour at 65° is given as ·617, and 100 is taken as saturation, therefore ·617 : ·478 : : 100 : 77·4, which is the relative humidity.

VIII.—ENGINEERING DATA, FORMULÆ, AND PROBLEMS.

The velocity acquired in one second by a body falling *in vacuo* at any part of the earth's surface is 32·18 feet per second, and is generally represented as g. The velocity acquired in half a second will therefore be $\frac{1}{2}g$ or 16·09, and in t seconds it will be gt. If distance be taken into account and denoted by s, and the velocity, at the end of time t, be denoted by v, the following formulæ can be deduced :—

$$v = gt \qquad \text{(a)}$$
$$s = \tfrac{1}{2}gt^2 \qquad \text{(b)}$$
and
$$v^2 = 2gs \qquad \text{(c)}$$

Example.—A stone dropped into a well is heard to reach the bottom in 6 seconds ; required the depth of the well to the surface of the water. (*Cambridge Examination*, 1886.)

Here it is required to find s by formula (b)—

$$\begin{aligned} s &= \tfrac{1}{2}gt^2 \\ &= 16·09 \times 36 \\ &= 579·24 \text{ feet.} \end{aligned}$$

The term "head of water" is applied to the height of the surface of water above any orifice, or rather the centre of the orifice, through which the water discharges, and represents the pressure of the water at the orifice. In a uniform liquid at rest, such as water, the intensity of pressure is the same at all points at the same depth. Hence the necessity of regulating the strength of distributing pipes in a public water-supply according to the head of water. Thus, suppose that a pipe is full at the orifice of a tap,

and that it is connected with a reservoir ; the tap is 100 feet below the level of the discharge pipe from the reservoir, which is 15 feet deep at this point, then the pressure in the pipe would be equal to a head of 115 feet. This is called the "hydrostatic pressure," in contradistinction to the term "hydraulic pressure," which represents the pressure in flowing water, and is therefore a variable pressure.

What is called "loss of head" applies to the diminished pressure due to friction in pipes, or to the lowering of the level of water in a cistern or reservoir where the pipes are discharging.

The theoretical velocity of water discharging from an orifice in a cistern or tank full of water is based on the following formula, known as Toricelli's, viz. $v = \sqrt{2g\mathrm{H}}$, where v = velocity in feet per second, $g = 32{\cdot}18$, the constant dynamical measure of the force of gravity, and H = head of water in feet. Thus, if a cistern 16 feet deep is discharged through an orifice in the bottom, the velocity per second will be

$$\sqrt{2 \times 32{\cdot}18 \times 16} = \sqrt{1029{\cdot}76}$$

or 32 feet nearly, a result which corresponds to the constant g.

The above formula may be varied thus: $v = \sqrt{2g\mathrm{H}} = \sqrt{2g} \times \sqrt{\mathrm{H}}$, and $\sqrt{2g} = \sqrt{64{\cdot}36} = 8{\cdot}025$ nearly, which is used as a constant.

To find the theoretical velocity of water issuing from an orifice, whether in the bottom or side of a vessel, the following therefore is the usual formula used : $v = 8{\cdot}025\sqrt{\mathrm{H}}$.

The numerous formulæ prepared by engineers, for calculating the velocity of discharge, the quantity per minute, and other data, though based on the above formula, are varied by means of co-efficients and other alterations of method which have been tested by experiment to suit particular conditions. The actual velocity, even in the above instance, is much less than the theoretical velocity. Thus, suppose the orifice is in a thin plate, as in an iron cistern, the formula becomes $v = 8{\cdot}025\sqrt{\mathrm{H}} \times {\cdot}615$ (Box).

To find the discharge in gallons, from such an orifice, the formula is $\mathrm{Q} = \sqrt{\mathrm{H}} \times d^2 \times 16{\cdot}3$. When Q = gallons discharged per minute, and d = diameter of pipe in inches, and H = head of water in feet.

If the discharge is through a pipe whose length is four times its diameter, the discharge is 84 per cent; if, through a *vena contracta*, that is, when a pipe first contracts and then widens out, the discharge is still greater, amounting to 97 per cent. With a pipe of considerable length, loss by friction greatly diminishes flow.

For instance, a pipe $1\frac{1}{3}$ inches diameter, and 30 feet long, discharges only one-half what a simple orifice of the same diameter would discharge. When running full, the circular pipe discharges a larger quantity than any other form of pipe. To sum up,—the quantity discharged at the outlet of any pipe depends upon the velocity of flow, and is affected materially by the length and diameter of the pipe, by the number and kind of bends, by the effective head of water, and in a slight degree by the shape of the entry or orifice. In the case of long pipes the effect produced by friction is so very great as to form the chief factor in hydraulic calculations, and numerous formulæ with tables of co-efficients have been prepared by which approximately accurate results may be obtained. For example, Hughes gives the following formulæ :—

Let V = Velocity in feet per second,
D = Diameter of pipe in feet,
H = Inclination of pipe in feet per mile,

then $$V = \sqrt{\frac{DH}{2 \cdot 3}}, \quad D = \frac{2 \cdot 3 V^2}{H}, \text{ and } H = \frac{2 \cdot 3 V^2}{D}.$$

Example.—Required the velocity of water issuing from a pipe 2 feet in diameter, 4 miles in length, and connecting two reservoirs, one of which is 30 feet above the other.

Here $D = 2$, $H = \frac{30}{4} = 7 \cdot 5$, or $7 \cdot 5$ feet fall per mile,

therefore $$V = \sqrt{\frac{2 \times 7 \cdot 5}{2 \cdot 3}} = \sqrt{6 \cdot 52} = 2 \cdot 55 \text{ feet per second.}$$

Hurst gives the following formulæ for calculating the flow of water in rivers and open channels :—

$$V = 95 \sqrt{\frac{A \times F}{P + L}}, \text{ and } Q = A \times V,$$

where A = Sectional area of water-way in square feet,
F = Fall in given length L in feet,
L = Length in feet,
P = Wetted perimeter, or girth of bottom and sides of open channels in feet,
Q = Quantity discharged in cubic feet per second ;
and V = Velocity in feet per second.

In order to estimate the flow of comparatively small water-courses, it is usual to dam up the whole stream, and discharge the

water through some artificial channel of known dimensions, such as a long wooden trough, through a sluice, or over a sill or weir. In the first instance, the method of calculation is easy because all that is required is to take the velocity by means of a float in feet per second, and the sectional area in square feet, and the product of the two will represent the number of cubic feet discharged per second.

If a sluice is used, the method of calculation is roughly as follows :—Multiply area of sluice in square feet by five times the square root of head in feet, and this will give the discharge in cubic feet per minute ; or $Q = A \times 5\sqrt{H}$.

In this instance, H is the difference of level of the water above and below the dam, if the sluice is entirely under water, or the height of the level of water in the dam above the centre of the sluice, if the sluice is not under water.

In gauging water flowing over a sill, Molesworth lays down the following rules :—The waste-board must have a thin edge. The height must be measured from the top of the sill, or waste-board, to the level of the surface, where it is not affected by the overfall. The waste-board must have a free overfall. Then, if

H = Height of surface of water above sill in feet,
h = Ditto if measured in inches,
V = Velocity of water approaching the sill in feet *per second*,
C = Cubic feet discharged over each foot width of the sill *per minute*,

$$\left.\begin{aligned} C &= 214\sqrt{H^3} \\ &= 5{\cdot}15\sqrt{h^3} \end{aligned}\right\} \text{if the stream above the sill is not in motion,}$$
$$= 214\sqrt{H^3 + {\cdot}035\,V^2H^2} \text{ if in motion.}$$

For the storage of water in reservoirs, constructed in catchment basins, Hawksley's formula is as follows :—$D = \frac{1000}{\sqrt{F}}$, where F equals mean annual rainfall in inches, and D the number of days' supply to be stored. Thus, with a mean annual rainfall of 25 inches, the number of days' supply would be $\frac{1000}{\sqrt{25}} = 200$.

A certain amount, however, must be allowed for evaporation. The mean annual rainfall is taken as $\frac{5}{6}$ of the average annual rainfall.

In the case of water collected from roofs (see page 209), the loss by evaporation varies considerably according to the amount of rainfall, but may generally be stated as one-fifth.

Example.—If the sole water-supply to a village is the rain-

water collected from the roofs, what will be the daily allowance per individual if the roof-space per head be 50 square feet, and average rainfall 27 inches?

$$1 \text{ inch rainfall} = 4{\cdot}673 \text{ gallons per square yard.}$$
$$50 \text{ square feet} = 5{\cdot}5 \text{ square yards.}$$
$$\therefore \frac{4}{5}\left(\frac{(5{\cdot}5 \times 27 \times 4{\cdot}673)}{365}\right) = 1{\cdot}52 \text{ gallons daily.}$$

Sewers and Sewage.—With regard to the calculations for estimating the flow of sewage, it is generally required to ascertain the velocity and the discharge when the sewers are only partly filled. In the case of a circular sewer, the velocity is greatest when it is filled to $\frac{81}{100}$ of the diameter, and the quantity discharged is greatest when filled to $\frac{95}{100}$ of the diameter. In an oval sewer, however, the velocity is greatest when filled to $\frac{85}{100}$ of the height, and the discharge greatest when filled to $\frac{96}{100}$ of the same.

In all sewers the velocity varies as the square root of the fall, and the fall will be proportional to the square of the velocity.

Example.—A sewer has a fall of 3 inches in 10 feet, with a velocity of 5·5 feet per second, what fall would be necessary to give a velocity of 11 feet per second?

$$\textit{Ans.}— \; 5{\cdot}5^2 : 11^2 :: 3 \text{ inches in } 10 : X,$$
$$30{\cdot}25 : 121 :: 3 \text{ inches in } 10 : X,$$
$$1 : 4 :: 3 \text{ inches in } 10 : X,$$
$$\therefore X = 4 \times 3 = 12 \text{ in. in 10 feet, or 1 in 10.}$$

Example.—If a sewer having a circular cross section of 2 feet diameter, running one-half full, conveys 1000 gallons of sewage per minute, what diameter would you require for a circular sewer (running half full) to carry double the quantity, the inclination remaining the same? (*Edinburgh University Examination.*)

Let x = radius required,

then
$$1 : 2 :: \pi r^2 : \pi x^2$$
$$1 : 2 :: r^2 : x^2$$
$$1 : 2 :: 1 : x^2$$
$$\therefore x^2 = 2, \text{ and } x = \sqrt{2},$$
$$\therefore \text{diameter} = 2\sqrt{2} = 2{\cdot}82 \text{ feet.}$$

Example.—If a nine-inch sewer with an inclination of 1 in 150 gives a velocity of 3·5 feet per second, what velocity will it give when laid at an inclination of 1 in 600 (the pipe running full in each case)? (*London University Examination.*)

The velocity is proportional to the square root of the fall.

Here the inclination of the two sewers is as 1 to 4,

$$\therefore \sqrt{4} : \sqrt{1} :: 3{\cdot}5 : x,$$
$$2 : \quad 1 :: 3{\cdot}5 : x,$$
$$\therefore x = 1{\cdot}75 \text{ feet per second.}$$

The formula for calculating the flow of sewage in circular sewers (see p. 321) is—

$$V = 55\sqrt{D \times 2F.}$$

where D = Hydraulic mean depth in feet,
V = Velocity in feet per minute,
and F = Fall in feet per mile.

Example.—What is meant—(*a*) by the "head" of a particle of water in a stream; (*b*) "hydraulic mean depth"? The velocity of a stream of water is 110 feet per minute, and its fall 8 feet per mile, what is approximately its hydraulic mean depth? (*Cambridge Examination*, 1891.)

(*a*) The "head" in this instance represents the fall of the stream in a measured length, as in the question 8 feet per mile. (*b*) The "hydraulic mean depth" is the sectional area of the current divided by the wetted perimeter. For the last part of the question the above formula becomes

$$110 = 55\sqrt{D \times 2 \times 8,}$$

$$\frac{110}{55} = \sqrt{D \times 16,}$$

$$2 = \sqrt{D \times 16,}$$

$$\therefore 4 = D \times 16, \text{ and } D = \frac{4}{16} = {\cdot}25 \text{ feet.}$$

In circular sewers running full or half full, the hydraulic mean depth is always $\frac{1}{4}$ the diameter, or $\frac{1}{2}$ the radius. This is shown as follows:—Let r = radius of the section; then $2\pi r$ = the perimeter, and the section of fluid or area of circle $= \pi r^2$, and $\dfrac{\pi r^2}{2\pi r} = \dfrac{r}{2} =$

$\frac{1}{2}$ radius or $\frac{1}{4}$ diameter. Again, suppose a pipe is running half full, the wetted perimeter in this instance $= \frac{2\pi r}{2} = \pi r$, and the sectional area $= \frac{\pi r^2}{2}$; then $\frac{\frac{\pi r^2}{2}}{\pi r} = \frac{\pi r^2}{2} \times \frac{1}{\pi r} = \frac{\pi r^2}{2\pi r} = \frac{r}{2}$, the same as before.

It is sometimes stated that the hydraulic mean depth in circular sewers is always $\frac{1}{4}$ the diameter, or $\frac{1}{2}$ the radius, whether they run full or half full, or not; but this is by no means the case, as the following table will show (Maguire):—

1. Table of Hydraulic Mean Depths of Circular Drains.

	Full.	Three-quarters full.	Two-thirds full.	Half full.	One-third full.	Quarter full.
4-inch	·0835	·1006	·0970	·0835	·0621	·0489
5-inch	·1042	·1315	·1216	·1042	·078	·064
6-inch	·125	·1508	·1456	·125	·0931	·0733
9-inch	·1875	·2263	·2183	·1875	·1396	·11
12-inch	·25	·3017	·2911	·25	·1862	·1466
15-inch	·3125	·3771	·3639	·3125	·2327	·1833
18-inch	·375	·4525	·4367	·375	·2793	·2199

After obtaining the velocity V, the quantity discharged in cubic feet per minute will be represented by VA, when A represents the sectional area of the current. These areas, in different drains and of varying depths, are given in the following table:—

2. Table of Sectional Areas in Square Feet of Water in Circular Drains.

	Full.	Three-quarters full.	Two-thirds full.	Half full.	One-third full.	Quarter full.
4-inch	·0873	·0762	·0618	·0436	·0255	·017
5-inch	·1363	·1096	·0972	·0681	·0391	·0267
6-inch	·19634	·158	·139	·09817	·0573	·0384
9-inch	·4418	·3554	·313	·2209	·1289	·0864
12-inch	·7854	·6318	·556	·3927	·2292	·1535
15-inch	1·227	·9873	·869	·6135	·3581	·24
18-inch	1·767	1·422	1·25	·884	·5157	·3455

The relations of the internal dimensions in an egg-shaped sewer are given by Molesworth as follows :—

Let $B =$ Diameter of bottom of sewer.
$C =$ Diameter of top of sewer.
$R =$ Radius of sides of sewer.
$D =$ Depth of sewer.

Then $B = \frac{D}{3}$, $C = \frac{2D}{3}$, and $R = D$.

For calculating the velocity and discharge of egg-shaped sewers flowing $\frac{2}{3}$ full, Hurst gives the following formulæ :—

$$V = 15{\cdot}3 \sqrt{\frac{d \times F}{L}} = \text{Velocity in feet per second.}$$

$$Q = 11{\cdot}56 \sqrt{\frac{d^5 \times F}{L}} = \text{Discharge in cubic feet per second,}$$

d, being the greatest transverse diameter in inches.

IX.—AIR AND VENTILATION, DATA, PROBLEMS, Etc.

All gases expand equally when heated through the same number of degrees, viz. $\frac{1}{273}$ of their volume for every degree Centigrade, and $\frac{1}{491}$ for every degree Fahrenheit.

If $A =$ volume of gas,
$T =$ original temperature (Fahr.),
$t =$ final temperature (Fahr.),

then
$$\text{Final volume} = \frac{a(491 + t)}{491 \times T}.$$

If it be desired to correct for pressure and temperature, the formula becomes

$$\text{Final volume} = \frac{aH(491 + t)}{h(491 + T)},$$

where $H =$ standard barometric pressure,
and $h =$ observed barometric pressure.

The laws which govern ventilation are based primarily on the laws applying to falling bodies and fluids already described (see *ante*).

Example.—Suppose two ventilating shafts,—the distance from the floor of the room to the point of exit being 50 feet in both cases. Shaft A is straight, circular in section, diameter being 8 inches; shaft B is bent twice at a right angle, the cross section being rectangular, 10 inches by 5 inches. The inside temperature of room in each case is 65° F.; outside temperature, 49° F. What are the respective quantities of air per hour that may be expected to pass out of the shafts ?

N.B.—Show the working of your calculation. (*Cambridge Examination*, 1885.)

For explanation and De Chaumont's formula, see p. 153.

Answer.—Here the height of the heated column is 50 feet, and difference of temperature 16° Fahr.

$$\therefore \frac{50 \times 16}{491} = 1 \cdot 71$$

and $$\text{velocity} = 8\sqrt{1 \cdot 71} = 10 \cdot 4 \text{ ft. per second.}$$

Now the velocity multiplied by the sectional area in feet gives the discharge in cubic feet per second.

Shaft A is 8 inches in diameter

$$\therefore \text{area} = D^2 \times \cdot 7854, \text{ or } \cdot\dot{6} \times \cdot\dot{6} \times \cdot 7854 \text{ or } \cdot 35 \text{ feet;}$$
$$\text{and } \cdot 35 \times 10 \cdot 4$$
$$= 3 \cdot 64 \text{ cubic feet per second,}$$
$$= 218 \cdot 4 \text{ cubic feet per minute,}$$
$$= 13104 \text{ cubic feet per hour.}$$

But about $\frac{1}{4}$th has to be deducted for friction ;

$$\therefore \tfrac{3}{4}(13104) = 9928 \text{ cubic feet per hour from Shaft A.}$$

Shaft B, as before—

$$\text{Velocity} = \sqrt{1 \cdot 71} \times 8 = 10 \cdot 4,$$
$$\text{Sectional area} = 10 \times 5 = 50 \text{ sq. in.} = \cdot 347 \text{ sq. foot.}$$
$$\cdot 347 \times 10 \cdot 4 = 3 \cdot 6 \text{ cubic feet per second,}$$
$$= 216 \cdot 0 \text{ cubic feet per minute,}$$
$$= 12960 \text{ cubic feet per hour.}$$

But each right angle diminishes quantity by one-fourth, so that, allowing for friction, we have

$$\tfrac{1}{4}(12960) = 3240 \text{ cubic feet per hour.}$$

For calculating the size of outlets and inlets of air for effective ventilation, the following is De Chaumont's formula :—

$$\frac{D}{100\sqrt{H(T-t) \times \cdot 002}} = A$$

D = delivery required per hour. H = height of heated column of air. T = temperature of column. t = temperature of external air. A = area of outlet and inlet in square inches. ·002 = ratio of expansion for 1° F. 100 = a constant.

To calculate the delivery per hour, the area of inlet being given :—

$$D = 200\ (\sqrt{H(T - t \times \cdot 002})A.$$

200 = constant, obtained by multiplying the number of seconds in an hour by twice $\sqrt{16 \cdot 09} = 8$ nearly, and dividing by 144 square inches. A = area of inlet. H, T, t, as in preceding formula.

In England, 24 square inches of outlet and inlet per head is deemed sufficient (see page 152).

The following laws apply to the relations of temperature and pressure of air and gases :—

BOYLE'S OR MARIOTTE'S LAW.—This law is as follows :—*The temperature remaining the same, the volume of a given quantity of gas is inversely as the pressure which it bears ; or, For the same temperature, the density of a gas is proportional to its pressure.*

This law has of late been shown to be only approximately true, for Regnault found that air does not exactly follow Boyle's law, but experiences a greater compressibility, which increases with the pressure.

CHARLES'S LAW.—*The volume of a gas is directly proportional to its absolute temperature, reckoned from its absolute zero, that is, 273° C. below* 0° *C.*

The absolute zero is that degree of cold which ceases to affect a gas, as cold usually does.

GRAHAM'S LAW.—*The ratio of diffusion of gases is inversely proportional to the square roots of their relative weights or densities.*

The formulæ for calculating the cubic space of rooms or wards of various shapes and capacities are given in Chapter V., p. 159.

Example.—A circular ward, with a dome-shaped roof, requires to be measured ; the diameter is 36 feet, the height to centre of dome is 18 feet, and the height of the walls is 12 feet. Find the floor space and total cubic contents. How many patients should be placed in such a ward? (*Cambridge Examination*, 1883.)

Ans.—$(D^2 = 36 \times 36) \times \cdot 7854 = 1017 \cdot 8784$ = square feet of floor space.

Cubic feet.

$1017 \cdot 8784 \times 12 = 12214 \cdot 5408$ = cubic contents of cylinder.

$1017 \cdot 8784 \times 6 \times \frac{2}{3} = 4071 \cdot 5136$ = cubic contents of dome.

$16286 \cdot 0544$ = Total contents of ward.

If the ward is intended for infectious cases, it should have a floor space of 144 square feet, and a cubic space of 2000 feet (see p. 421). Therefore, as only a small part of the dome can be taken into account, there is only room for 7 patients. In a general hospital 10 patients might be accommodated (see p. 403).

The amount of fresh air required per head under various circumstances, and De Chaumont's formula for calculations are given in Chapter IV.

Example.—Give an account of De Chaumont's experiments on the ventilation of inhabited rooms. What formula did he deduce from them, and of what use is that formula? (*Cambridge Examination*, 1891.)

For answer, see pp. 123, 124.

Example.—Describe the methods of ascertaining the state of ventilation of a room. The air of a room occupied by 6 persons and containing 5000 cubic feet of space yields 7·5 parts of carbonic acid per 10,000 parts. How much air is being supplied per person per hour? (*Cambridge Examination*, 1884.)

For first part of question, see Chapter V., p. 158.

For second part, see De Chaumont's formula, p. 123.

$e = Co_2$ exhaled per hour per person,
$r =$ observed ratio of vitiation,
$d =$ number of thousands cubic feet utilised.

Then

$$\frac{\cdot 6}{\cdot 75 - \cdot 4 \text{ (amount in air)}} = 1\cdot 714 \text{ thousands,}$$

or 1714 feet per person per hour.

For particulars concerning the vitiation of air by respiration, see p. 95, and by combustion, see p. 102.

Coal gas has an average composition of :—

	In 100 parts.
Hydrogen	42
Light carburetted hydrogen (CH_4)	38
Carbon monoxide	4·5
Olefiant gas (ethylene, C_2H_4)	3·5
Acetylene (ethine, C_2H_2)	2·5
Hydrogen sulphide	0·5
Nitrogen	2
Carbon dioxide	3
Sulphur dioxide	0·5
Ammonium sulphide	traces
Carbon disulphide	traces

In ordinary gas combustion, the following products escape into the air :—

Nitrogen	67 per cent.
Water	16 ,,
Carbon dioxide	7 ,,
Sulphur dioxide	small quantities.
Ammonia	,,

Carbon monoxide, 5 per cent; but with perfect combustion, none.

One cubic foot of gas unites with from 0·9 to 1·64 cubic feet of oxygen (8 cubic feet of air), producing 2 cubic feet of carbon dioxide, and from 0·2 to 0·5 grains of sulphur dioxide.

For warming by hot-water pipes the following data will be found useful :—

To find the length of 4-inch pipe to warm a church.—Divide the cubic contents of the church by 200, the result will be the length of pipe required.

The length of pipe required for dwelling-rooms.—Twelve feet of 4-inch pipe for every 1000 cubic feet to warm to 65° F.

The length of pipe required for work-rooms.—Temperature, 50° to 55° F., six feet of 4-inch pipe per 1000 cubic feet.

The length of pipe required for school and lecture-rooms.—55° to 58° F., six feet of 7-inch pipe per 1000 cubic feet.

Every square foot of glass will cool 1·279 cubic feet of air as many degrees per minute as the internal temperature of the room exceeds the temperature of the external air.

X.—FOOD AND WORK (see p. 28).

Useful Tables.

Diet for Ordinary Labour.	
Albuminates . .	4·5
Fat	3·5
Carbo-hydrates . .	14 to 14·25
Salts	1
Total dry food .	23·0

1 Oz.	N. grs.	C. grs.	Foot-tons.
Dry Albuminates	= 70	213	= 173
Fat . .	= —	336	= 378
Carbo-hydrates	= —	190	= 135

	100 Parts.				Grains per pound.	
	Albuminates.	Fats.	Carbo-hydrates.	Salts.	N.	C.
Cooked Meat .	27.5	15·75	—	3	190	1900
Bread . .	8	1·5	49	1·3	90	2000
Potatoes .	2	·16	21	1	22	770
Butter . .	1	90	—	1	—	6500
Cheese . .	31	28·5	—	4·5	300	3300
Milk . .	4	3·5	5	·7	45	600

Example.—How much oatmeal, milk, and butter, of the following percentage composition would furnish the albuminates, fats, and carbo-hydrates, for an average diet?

Would the salts be in the proper proportion or not?

	Water.	Albuminates.	Fats.	Carbo-hydrates.	Salts.
Oatmeal . .	19	12	6	60	3
Milk . .	87·3	4	3	5	0·7
Butter . .	14	0	84	0	2

(*Cambridge Examination*, 1882.)

The albuminates, fats, carbo-hydrates, and salts necessary, may be laid down as follows:—

Albuminates	4·5	ounces.
Fats	3	,,
Carbo-hydrates	14·25	,,
Salts	1	,,

Let x = number ounces oatmeal required.
,, y = ,, milk ,,
,, z = ,, butter ,,

$$(1)\ \frac{12x+4y}{100}=4{\cdot}5$$

$$(2)\ \frac{6x+3y+84z}{100}=3$$

$$(3)\ \frac{60x+5y}{100}=14{\cdot}25$$

$$(1)\ 12x+4y=450$$
$$(2)\ 6x+3y+84z=300$$
$$(3)\ 60x+5y=1425$$

Multiply (1) by 5—

$$\begin{aligned} 60x+20y&=2250 \\ 60x+5y&=1425 \\ \hline 15y&=825 \\ \therefore\ y&=55 \text{ oz. milk.} \end{aligned}$$

$$\begin{aligned} 12x+4y&=450 \\ 12x+220\ (4\times 55)&=450 \\ 12x&=450-220=230 \\ \therefore\ x&=\frac{230}{12}=19{\cdot}16 \text{ oz. meal.} \end{aligned}$$

$$\begin{aligned} 6x+3y+84z&=300 \\ 114{\cdot}96+165+84z&=300 \\ 84z&=300-(114{\cdot}96+165) \\ \therefore\ z&={\cdot}24 \text{ oz. butter.} \end{aligned}$$

Salts.

100 milk	: 55	: : 7	:	·385
100 meal	: 19·16	: : 3	:	·5748
100 butter	: ·24	: : 2	:	·0048
				·9646

The quantity of salts is thus rather small.

Example.—How is work calculated? Suppose a man weighing 160 lbs. in his clothes carries a hod of bricks weighing 40 lbs. up a perpendicular ladder 30 feet high, 100 times a day, what amount of work does he do? What would this be equal to in miles walked upon a flat surface at 3 miles an hour? (*Cambridge Examination*, 1886.)

For first part of question, see p. 31.

Second part :—

$$\frac{(160+40)\times 30\times 100}{2240}=267{\cdot}8 \text{ foot-tons.}$$

Third part :—Professor Haughton has shown that walking 3 miles an hour is equivalent to raising $\frac{1}{20}$th the body weight through the distance walked (see p. 32). The formula is $\frac{(W+W')\times D}{20\times 2240}$, where W is the weight of the person, W′ the weight carried, D the distance walked in feet, 20 the coefficient of traction, and 2240 the number of pounds in a ton, the result is the number of tons raised 1 foot. By multiplying 5280 by the number of miles walked we get the distance in feet, and multiplying the work done, namely 267·8 foot-tons, by 2240, we reduce tons to pounds. Hence the equation becomes,

$$267{\cdot}8\times 2240=\frac{(160+40)\times 5280\,D}{20},$$

$$\therefore\ D=11{\cdot}34 \text{ miles (at 3 miles an hour).}$$

APPENDIX B

EXAMINATIONS AND EXAMINATION PAPERS

The problems in Appendix A have been selected, and the following questions are given, to show the general scope of the examinations for diplomas or certificates in Sanitary Science or State Medicine, which are open to all candidates who were duly qualified and registered on or before 1st January 1890. For candidates qualifying after that date, the General Medical Council have issued certain regulations which prescribe a six months' course of laboratory work after qualification, and a six months' course of practical training under the medical officer of health of a county or large urban district. Most of the universities, with the exception of Cambridge, Durham, and the Victoria University, restrict their examinations to their own graduates; but these three universities, together with the Royal College of Physicians of London and the Royal College of Surgeons of England, the Royal Colleges of Edinburgh, the Irish Colleges, and the Faculty of Physicians and Surgeons of Glasgow, throw open their examinations to all candidates who are duly qualified and registered. Some of the examining bodies divide their examinations into two parts; but the subjects in which candidates are required to show proficiency are very similar in all. In addition to answering questions in writing, candidates are examined orally, and most examinations, in addition to physics and sanitary engineering, comprise practical work with special reference to the analysis of air and water, and the application of the microscope to food adulterations, entozoa, parasitical diseases, and turbid waters. Such practical knowledge can, of course, only be gained by laboratory work under a recognised teacher. It is also very desirable that all candidates should take every opportunity of gaining practical experience by inspecting water-works, sewage-works, factories, hospitals, offensive trades, slaughter-houses, gas-works, etc., and of acquiring a full knowledge of sanitary appliances

as exhibited in the Parkes Museum, London, or other sanitary exhibitions.

The following questions have been selected indiscriminately from the Cambridge University Examination papers for the years 1889, 1890, and 1891, and, for the convenience of the student, references are appended to each question to particular pages throughout the body of the work and to Appendix A for answer :—

1. How may the direction and the rate of movement of air in a room be determined? If a room of 1500 cubic feet capacity be continuously inhabited by two adults, what would be the rate per minute at which fresh air should enter to keep the atmosphere sufficiently pure? Show how you arrived at your result. (See pp. 161 and 123.)

2. Explain exactly how (*a*) height above the sea, and (*b*) distance from the sea, affect the climate of a place. (See pp. 173, 174, and 191, 192.)

3. Describe Clark's test for the determination of the hardness of a water. What information may be obtained by the use of this test alone? (See pp. 251-254.)

4. Explain the actions of peroxide of nitrogen, chlorine, ozone, and sulphurous acid upon refuse organic matters in the air. (See pp. 528, 529.)

5. Upon what principles does natural ventilation depend? Explain Montgolfier's formula. How far can it be relied on? (See pp. 131 and 153.)

6. How much work expressed in foot-tons may be expected from a man who has a diet of 12 oz. cooked beef, 30 oz. bread, 2 oz. butter, and 70 oz. water in the 24 hours? (See *ante*, p. 726, and pp. 29-32.)

7. In what respects as to the kind and quantities of its constituents does "ground-air" differ from ordinary atmospheric air, and how is it affected by the movements of the atmosphere and of the water in the soil? (See pp. 367-369.)

8. What is meant by the term "temporary hardness," "permanent hardness," and "total hardness" as applied to water, and to what substances are these forms of hardness respectively attributable? What degree of hardness would entitle a water to be termed "hard"? By what means may hard waters be softened? Explain exactly what takes place during the process of softening. (See pp. 251-254, and 232.)

9. Sketch and describe a good form of hopper-closet and its connection with a house-drain. What are the advantages of this form of closet? How should it be supplied with water? (See pp. 298, 305, and 299.)

10. What is meant by the "mean duration of life"? How is it estimated from the birth- and death-rates? How far is it a good test of the health of a community? (See p. 581.)

11. How are death-rates calculated? If you know the population and death-rates of two districts, how can you calculate the death-rate of the combined district? If the population of one district be 21,575, and the death-rate 18 per 1000 per annum, and that of another 29,864, with a death-rate of 20, what is the death-rate of the combined district? (See pp. 562, 563.)

12. How should a house-drain be constructed as regards material, form, size, fall, ventilation, and connection with water-closets, sinks, and the sewer? (See pp. 306-316.)

13. Describe three methods of disposing of town sewage, stating the principles on which they are based, the conditions under which they are applicable, and their efficiency in converting sewage into innocuous chemical substances. (See pp. 345-354.)

14. What is meant by syphonage of water-traps? Explain the conditions under which it takes place. (See p. 306.)

15. What do you understand by the term "insusceptibility"—(1) generally in reference to any communicable disease; (2) especially in reference to vaccination and the language of the Vaccination Acts? Give, under either head, any statistics with which you are acquainted. (See pp. 428, 440-444, and 448.)

16. What are the powers of urban sanitary authorities for dealing with "unhealthy areas"? What evidence is required to show that a locality is an "unhealthy area"? (See pp. 664-666.)

17. What are the diseases the notification of which is required under the "Infectious Diseases (Notification) Act, 1889"? What are the provisions of the Public Health Act against the spread of infection? (See, in order, pp. 673, 613, 626-629, and 638.)

18. What is the evidence as to the relation of vaccination marks to:—
(1) Attacks from smallpox;
(2) Deaths from smallpox?

What is the incubation period of smallpox and vaccinia respectively? How would your knowledge in this respect influence your practice when persons unprotected, or not fully protected by primary vaccination, are exposed to the infection of smallpox? (See pp. 437-448.)

19. Give a short account of the diseases which have been known to result from eating the flesh of the pig in this country. (See pp. 71-75, and 495.)

20. Are you of opinion that a running stream of water which has become unfit for drinking purposes on account of the admission of town sewage into it, may, after a flow of some miles, again become

fit for drinking, and that it may be safely used as an ordinary town supply? Give the reasons for your opinion *pro* or *contra*. (See pp. 212 and 279.)

21. A healthy child is vaccinated on the left arm with tube-lymph (source unknown) at an ill-ventilated urban dispensary crowded with patients. On the fourth day erysipelas appears on the right arm. Discuss the question of the probable causation of the erysipelas. (See pp. 448-450.)

22. The water-supply of a large town is derived from a gathering ground of open moor and enclosed pasture, including a small hamlet and some scattered farmsteads. The subsoil is a fissured sandstone. The water is collected by a rough stone-built conduit at the foot of the slope, and carried to an open reservoir, whence it is distributed by gravitation. Discuss fully the question of the probable wholesomeness of the water as delivered in the town. (See pp. 225, 278, and 285-288.)

23. Describe, and compare the advantages of, the chief modes of disinfection generally in use. (See pp. 518-522, 524, and 532.)

24. What is the meaning of the words in the Public Health Act "a nuisance or injurious to health"? Enumerate in order the several steps that have to be taken to obtain the abatement of a nuisance, defining exactly the powers of a sanitary official, a sanitary authority, and a court of summary jurisdiction. (See pp. 615, and 618-620.)

25. What are the different methods of procedure which may be enforced with a view of preventing the spread of infectious diseases through the agency of elementary schools; and by what circumstances would you be guided in advocating one or other method? (See pp. 510, 516.)

26. You are called upon as a medical officer of health to decide whether the carcases of a number of sheep affected with the distoma hepaticum (liver fluke) may be passed as fit for food. Describe the appearances you would expect to find, and indicate the grounds on which you would form your decision. (See p. 46.)

27. Near the centre of a town of 15,000 inhabitants is situate the premises of a candle-maker. Complaints are made to you as medical officer of health of serious and frequent nuisance arising therefrom. What action would you take in such a case? Describe in detail the methods by which nuisances from candle-houses have been prevented. (See pp. 621-624.)

28. Give the meaning of the expressions "standard death-rate," "factor for correction," and "comparative mortality figure," as used by the Registrar-General. What are the fallacies involved in the use of so-called *general death-rates*, as a means of comparing

different communities, with respect to their health? (See pp. 570, 572, and 568.)

29. Explain what is meant by the expressions "ground air" and "ground water"; what is the nature of the influence which, under certain circumstances, they may severally exert on the public health? (See pp. 367, 369, and 370-373.)

30. In certain instances the public health is known to have suffered because of the unwillingness of local authorities to put in force the powers which they possess for securing the proper sanitary condition of their districts. State the provisions contained in recent enactments which render it obligatory on sanitary authorities to fulfil their statutory duties in this respect. (See pp. 636, 647, 666, and 670.)

31. Under what circumstances may "overcrowding" be dealt with under the Public Health Act, 1875? Assuming that a party has been proceeded against under Section 91, what further powers are possessed by a sanitary authority for the prevention of overcrowding? (See pp. 615, 618, and 620.)

32. To what diseases are the following classes of operatives especially liable—file-cutters, knife-grinders, painters, brass-workers, and lacemakers? Why is the mortality amongst Cornish miners so much heavier than amongst the miners of Lancashire? (See pp. 111-116.)

33. What considerations would influence you in advising a sanitary authority as to the necessity of providing fever-hospital accommodation for a combined district, mainly rural in character, but containing important village communities within its area? (See pp. 412-416.)

34. A member of a family of school children is attacked by scarlet fever. The patient is nursed at home, although the house is too small to allow of his satisfactory isolation, and therefore the other children are temporarily forbidden to attend the day-school. For what period after the complete recovery of the patient, the disinfection of the house, etc., would you consider it necessary to keep his brothers away from school? State the reasons for your answer. (See pp. 454 and 516.)

The following questions have been selected from the papers given in the conjoint examinations of the Royal College of Physicians of London, and the Royal College of Surgeons, England, during 1890-91:—

1. How is the dew-point ascertained? Explain its relations to the humidity of the atmosphere and to the evaporation of liquids. (See pp. 193, 194.)

2. It is proposed to warm and ventilate an occupied room by means of warmed air. Describe the means you would adopt, and

the precautions you would take in effecting this. (See pp. 140, 146.)

3. What is meant by "ground-water"? What are its relations to the soil and to water-courses? Explain the general character of its movements. (See pp. 369, 370.)

4. Describe in detail one good process for determining the proportion of carbon dioxide in the atmosphere of a room, and explain the process adopted. (See pp. 165-167.)

5. State exactly how you would proceed to examine a turbid water-supply. Briefly describe the substances which may thus be discovered which may affect your judgment as to the fitness of the water for drinking purposes. (See pp. 240, 241.)

6. Explain the methods and discuss the comparative advantages and disadvantages of ventilation (*a*) by propulsion, (*b*) by extraction. (See pp. 145-150.)

7. Give diagrams and full descriptions of a bad and of a good form of water-closet respectively, and state the grounds on which you approve of the one and object to the other. (See pp. 296-298.)

8. Describe the methods usually adopted for keeping walls dry in houses built upon a damp soil, and their relative degrees of efficiency. (See pp. 312, 381-384.)

9. What are the respective amounts of albuminoids, fats, carbohydrates, salts, and water required by a man weighing 170 lbs. and doing ordinary mechanical work? Give a dietary furnishing these amounts. (See pp. 29-32, and *ante* p. 724.)

10. What is meant by "albuminoid ammonia"? How is it estimated in a sample of water? What does its presence in vārious quantities indicate? (See, in order, pp. 261, 258, and 262.)

11. What should be the diameter, and what the fall of a house-drain? If a sufficient fall cannot be got, what should be done? What is the relation between fall and velocity of flow in pipes? (See, in order, pp. 312, 315, and *ante* p. 717.)

12. What is the average composition of town sewage? How has its theoretical value as a manure been estimated? How does lime act as a precipitant of sewage? (See pp. 342, 346.)

13. What are the conditions of soil which tend to the production of infantile summer diarrhœa? Give your views as to the methods by which these conditions severally act. (See p. 470.)

14. Give an account of the natural history of three of the parasites which infest the interior of the human body. Describe the symptoms to which they severally give rise. (See pp. 491-497.)

15. What are the conditions which you would hold in view in deciding whether, in a given case, there was unwholesome over-

crowding or not? How does overcrowding affect health injuriously? (See pp. 618, and 98-100.)

16. What is the evidence as to the relation of vaccination marks to:— (*a*) Attacks from smallpox; (*b*) Deaths from smallpox? (See pp. 442, 448.)

What are the statutory provisions relating to the sanitary regulation of bakehouses, and what are the responsibilities of medical officers of health with regard to their enforcement? (See pp. 652, 657.)

17. What powers do sanitary authorities possess to check the spread of smallpox through the agency of canal boats? Specify the statutes under which they would act. (See pp. 645, 626.)

18. How do atmospheric conditions affect the spread of measles, scarlet fever, whooping-cough, enteric fever, and smallpox? (See p. 205.)

19. Describe the manner in which milk may become an agency for the spread of scarlet fever, enteric fever, and diphtheria. Enumerate the features which characterise a milk epidemic. (See, in order, pp. 84, 89, 77, 90.)

20. Give a general account of the information available on the subject of the communication of tubercle from the lower animals to man. State how far you concur in, or dissent from, the views you refer to. (See pp. 45, 84, and 487.)

21. Describe and compare the advantages of the chief methods of disinfection generally in use for clothing, bedding, and dwellings. (See pp. 518, 529, and 532.)

22. It is desired in a given urban district to bring the common lodging-houses under proper control. What are the powers as to this under the Public Health Act, 1875? Give a summary account of the several matters which can be regulated, and explain, as to each, what regulation should be adopted. (See pp. 613, 614.)

APPENDIX C.—Note—These two tables are issued by the sheet is spaced to give the Statistics

(A)—TABLE OF DEATHS during the year 1891, in the ....

Diseases, Ages,

Names of Localities adopted for the purpose of these statistics Public Institutions being shown as separate Localities.	Mortality from all Causes at subjoined Ages.								1	2	3	4
	At all ages.	Under 1 year.	1 and under 5.	5 and under 15.	15 and under 25.	25 and under 60.	60 and upwards.		Smallpox.	Scarlatina.	Diphtheria.	Membranous Croup.
(a)	(b)	(c)	(d)	(e)	(f)	(g)	(h)	(i)				
								Under 5.				
								5 upwards.				
								Under 5.				
								5 upwards.				
Totals								Under 5.				
								5 upwards.				

The subjoined numbers have also to be taken into account

Deaths occurring outside the district among persons belonging thereto.								Under 5.				
								5 upwards.				
Deaths occurring within the district among persons not belonging thereto.								Under 5.				
								5 upwards.				

(B)—TABLE OF POPULATION, BIRTHS, and of NEW CASES of Health, during the year 1891, in the .... Sanitary District of

Names of Localities adopted for the purpose of these statistics; Public Institutions being shown as separate Localities.	Population at all Ages.	Registered Births.	Aged under 5 or over 5.	New Cases of Sickness the knowledge of the					
				1	2	3	4	5	6
	Census 1891.			Smallpox.	Scarlatina.	Diphtheria.	Membranous Croup.	Typhus.	Enteric or Typhoid.
(a)	(b)	(c)	(d)						
			Under 5.						
			5 upwards.						
			Under 5.						
			5 upwards.						
Totals			Under 5.						
			5 upwards.						

Local Government Board on separate sheets (see p. 697), and each of Ten Different Localities.

Sanitary District of ...., classified according to and LOCALITIES.

MORTALITY FROM SUBJOINED CAUSES, DISTINGUISHING DEATHS OF CHILDREN UNDER FIVE YEARS OF AGE.																	
5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
FEVERS.																	
Typhus.	Enteric or Typhoid.	Continued.	Relapsing.	Puerperal.	Cholera.	Erysipelas.	Measles.	Whooping-Cough.	Diarrhœa and Dysentery.	Rheumatic Fever.	Ague.	Phthisis.	Bronchitis, Pneumonia, and Pleurisy.	Heart Disease.	Injuries.	All Other Diseases.	TOTAL.
....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
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in judging of the above records of mortality.

....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....

INFECTIOUS SICKNESS, coming to the knowledge of the Medical Officer of ....; classified according to DISEASES, AGES, and LOCALITIES.

IN EACH LOCALITY, COMING TO MEDICAL OFFICER OF HEALTH.							NUMBER OF SUCH CASES REMOVED FROM THEIR HOMES IN THE SEVERAL LOCALITIES FOR TREATMENT IN ISOLATION HOSPITAL.												
7	8	9	10	11	12	13	1	2	3	4	5	6	7	8	9	10	11	12	13
FEVERS.											FEVERS.								
Continued.	Relapsing.	Puerperal.	Cholera.	Erysipelas.			Smallpox.	Scarlatina.	Diphtheria.	Membranous Croup.	Typhus.	Enteric or Typhoid.	Continued.	Relapsing.	Puerperal.	Cholera.	Erysipelas.		
....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
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Author's Form for Return of Births and Deaths (see page 606).

* ....Sanitary District of .... Sub-registration District of ....

Return of Births and Deaths for the week ending the ....th day of ... . 189 ....

Births { Legitimate, M..........., F........... ; Illegitimate, M. ...., F .... } Total .... Deaths, M ...., F............ Total ....

Register No.	Date of Death.	† Residence.	Name and Surname.	Sex.	Age.			Occupation or Calling.	Causes of Death.	By whom Certified.
					Years.	Months.	Days.			

* Insert Urban or Rural.
† Give previous residence of persons dying in public institutions.

Signed ...., *Registrar*.

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THE END.

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